METALLURGIA

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Architectural Uses of Aluminium Applied in the Building of New Laboratories

The new Banbury Laboratories of the Northern Aluminium Co., Ltd., provide another indication of the rapid development and application of aluminium and its alloys, the object of which is not only to promote further development, but in order to maintain high standard of quality. Aluminium alloys have been used for various architectural purposes in the new building, and in this article a brief description of these laboratories is given. It is noteworthy that new laboratories are also in course of construction at the company's Birmingham works.

ALUMINIUM and aluminium alloys have already proved their usefulness in a variety of ways for structural and decorative purposes in both exterior and interior work, and full advantage has been taken of them in the construction of the new laboratory and office building, recently erected at the Banbury Works of the Northern Aluminium Co., Ltd., by Messrs. Hinkins and Frewin, of Oxford, to the plans of Mr. Lloyd F. Ward, A.R.I.B.A., of Birmingham.

The main activities of the company at their Banbury works are the manufacture of sheet, extruded and drawn products in aluminium and aluminium alloys, together with the manufacture of " Noral " paste, which last is used as a pigment for aluminium paint.

The very great increase in the demand for the company's products rendered existing laboratories inadequate to cope with the extra amount of control and research work necessary to maintain the high standard of quality and develop new products. Some twelve months ago, therefore, it was decided to build the present laboratories, to which the technical staff have now been transferred. New research and control laboratories are also in course of construction at the company's Birmingham works.

The new laboratory building at Banbury is 150 ft. long and 53 ft. wide. It is a well-lighted, two-storey building constructed of stone and brick. Anodised aluminium window frames, supplied by Messrs. James Gibbons, Ltd., of Wolverhampton, and made from the Northern Aluminium Co's N.A. 51 S Q extruded sections, have been used for the windows on the whole of the front and at both ends of the building. Aluminium alloy spandrels, cast at the Northern Aluminium Co.'s Birmingham foundry, in the N.A. 123 alloy, have been used for decorative effect on the outside of the building below the upper floor windows. The very striking entrance doors, cast in the company's N.A. 123 alloy, were anodised and supplied by Messrs. H. H. Martyn and Co., of Cheltenham. The main staircase balustrade, supplied by Messrs. James Gibbons, Ltd., is made from highly polished N.A. 51 S Q extruded sections, and combines with the aluminium alloy entrance doors to give a very pleasing effect to the main entrance hall. Small internal fittings, such as door handles cast in N.A. 305 alloy, switch plates and reflectors made from N.A. 2 S sheet, are all anodised finish. The several photographs used as illustrations show the very effective and attractive manner in which aluminium castings, extruded sections and sheet can be utilised for the purposes mentioned.

The laboratories and mechanical testing department include a metallurgical laboratory, chemical laboratory, X-ray room, and technical library on the first floor, and mechanical testing department, machine shop, fatigue testing department, pyrometric department, and a large experimental remelting and heat-treatment room on the ground floor.

Metallurgical Research Laboratory and X-ray Rooms

The metallurgical laboratory equipment includes a Vickers projection microscope (Model 1), macro-photographic camera and electrolysis apparatus. The room set apart for X-ray work has a dark room adjoining, and is equipped with a Phillips A.C. 100 K.V. X-ray apparatus. A Hilger spectroscope is also installed here; spectrographic analysis having been made use of in the company's laboratories for several years.

That industrial progress depends largely on metallurgical research has always been fully recognised by the company, and the additional equipment now available, together with increased metallurgical staff, gives very greatly extended facilities for this branch of the technical department's work.

Chemical Laboratory

The chemical laboratory is an exceptionally well-lighted and well-ventilated room, having the whole of the walls white tiled. Efficient and ample fume-hood and fume cupboard space is provided, and since in addition there is in the roof of the laboratory a forced-draught ventilating system, the atmosphere is a decided improvement on that which is generally understood to be normal in chemical laboratories. This laboratory is equipped with large main working benches as well as a titration bench; this part of the equipment being supplied by Messrs. Baird and Tatlock, Ltd. Adjacent to the chemical laboratory are a well-equipped balance room and also a store room. Stairs are provided to the outside of the building, the flat roof of which is adapted for the exposure of corrosion test specimens to varying atmospheric conditions.

In addition to the usual analytical apparatus, the equipment of the chemical laboratory includes gas analysis apparatus, oil-testing apparatus, electric drying oven, and muffle and centrifuge.

It is interesting to note that anodised N.A. 51 S Q alloy window frames and anodised lighting reflectors made from N.A. 2 S aluminium have been used for the chemical laboratory.

The New Laboratories of the Northern Aluminium Company Ltd. at Banbury

(*Above left*) Mechanical test house and machine shop.

(*Above right*) The chemical laboratory.

(*Left*) Entrance door to main building, cast in NA123 alloy and anodised.

(*Right*) Part of fatigue testing room showing R.A.E. type sheet testing machine

(*Below*) Main building showing anodised NA5150 alloy window frames and NA123 cast aluminium alloy spandrels used for decorative effect.

(*Below left*) Part of experimental room showing "Birlec" heat-treatment furnace.

(*Below right*) Metallurgical laboratory showing Vickers' projection microscope.

A large staff of chemists is employed to carry out control tests on all raw materials, as well as to check the composition of every melt of metal used.

Mechanical Testing and Fatigue Testing

The mechanical testing department is situated in a large room, occupying over 1,500 square feet of the ground floor of the building. Adjacent to this is the room set apart for fatigue testing. The mechanical test-house equipment includes 30,000 lb. and 20,000 lb. Amsler tensile testing machines, 3,000 lb. Denison tensile machine, Izod impact machine, Erichsen sheet-testing machine, together with the necessary equipment for preparation of test-pieces, such as lathes, milling and drilling machines, machine saw, press and guillotine. The fatigue testing room contains Wöhler type rotating bar machines for rod and bar, and also sheet testing machines of the R.A.E. design. Additional machines of other makes and design are on order and in process of being installed.

Some hundreds of mechanical tests are carried out daily, and by these means, in addition to the chemical control on purity previously mentioned, all possible precautions are taken to ensure that only metal of the highest standard of quality is used for the finished droducts, and that such products comply with specifications in regard to chemical composition and mechanical properties.

Pyrometric Department

The production operations are under careful pyrometric control by means of automatic controls and load couples at all stages of the process from remelting to finished product, and the pyrometric department is fully equipped with all the apparatus necessary for the daily checking and calibration of pyrometric equipment.

Experimental Department

A large room situated on the ground floor is allotted to experimental work. The equipment here includes a "Birlec" electrically heated air heat-treatment furnace, with Foster automatic control, an "Efco" electrically heated nitrate heat-treatment furnace also fitted with Foster automatic control, and a Wild-Barfield electric remelting furnace. Quench and wash tanks are provided for use with the heat-treatment furnaces. In this room is also installed a Canning salt spray corrosion testing apparatus.

Experimental work and research are being carried out continually. This, coupled with the exceptionally close control over all stages of manufacture exercised in the extensive laboratories described above, shows the determination of the Northern Aluminium Co. to maintain their products at the high standard of excellence.

Modern Methods of Alloy Steel Analysis

By B. BAGSHAWE, Assoc. Met.

Steel analysis is one of the most involved and highly specialised branches of chemical science, and the author, in a recent lecture before the Midland Metallurgical Society, emphasised some of the developments of the chemist during the past thirty years which have revolutionised the whole structure of metallurgical analysis, an abridgement of which is given in this article.

THIRTY years ago steel analysis was regarded almost as the Cinderella of chemistry, but to-day it forms one of the most involved and highly specialised branches of chemical science. It is to the chemical pioneers that we owe the great developments of the present century which have revolutionised the whole structure of metallurgical analysis and enabled it to emerge from the obscurity which enshrouded it to the highly respectable position it occupies to-day. The particular line along which development has been most marked is a thorough investigation and understanding of the theory of hydrogen ion concentration and the effect of ammonium chloride and ammonium and sodium acetates on the suppression of hydrogen ion concentration. Along with this development and the consequent wider knowledge of PH values, there has developed not only a series of new oxidation reduction indicators, but also a wider understanding of the principles relating to the quantitative separation of elements from closely related numbers of the same family group. Another important feature has been the development of selective organic reagents to meet the need for reagents of a more or less specific character. So diverse are the possible combinations of elements in modern alloy steel that often the whole course of the analysis is determined by the particular nature of the alloy under examination. The problem of interfering elements is a very real one, and is constantly becoming more acute, and it is in this respect that the specific character of some of the organic reagents have been so advantageously exploited. Of these reagents, dimethyl glyoxime is perhaps the best known and easily the most important, in fact the discovery of this oxime by Tschugaeff in 1905 ranked as one of the greatest analytical developments of the century. Of the remaining organic reagents, a nitroso β-naphthol for cobalt, a benzoin oxime for molybdenum and cup-ferron for titanium and zirconium are perhaps the most valuable.

In a more detailed study of analytical methods, manganese is mentioned first. The bismuthate method leaves nothing to be desired for the plain carbon and nickel steels, and is too well known to merit more than passing reference. Persulphate oxidation in nitric acid solutions, followed by arsenite titration, is a well-known and largely used routine method, but it is limited to comparatively small amounts of manganese, and, in addition, depends for its success on empirical standardisation against a known source of manganese. This oxidation is, however, now available in an accurate modified form, which also permits the estimation of both chromium and vanadium in the same solution. Another rather novel method for estimating manganese and chromium together, depends upon a combined oxidation of both metals to their highest valence, with ammonium persulphate followed by selective titration of manganese with standard sodium nitrite, after which chromium is determined by completing the titration with $FeSO_4$ and $KMnO_4$.

The estimation of chromium in stainless and high chromium heat-resisting steel has been the subject of considerable investigation, with the object of speeding up the process. Most of the straight chromium stainless steels are readily soluble in dilute sulphuric acid, leaving only a carbide residue which is amenable to oxidation treatment with nitric acid. Solution in mixed sulphuric phosphoric acids is, on the whole, rather quicker than sulphuric acid alone. The use of mixed phosphoric and perchloric acid has recently assumed greater importance. Suitable mixtures of these two acids are remarkable solvents for all types of rustless and heat-resisting steels. This form of solution forms the basis of a comparatively new method, in which advantage is taken of the oxidising properties of perchloric acid at temperatures just above 20° C. However, the Vignall method is still the most commonly used in this country, in spite of the fact that it is much more time-consuming, and requires a greater degree of manipulative skill than either the perchloric or persulphate methods. Although accurate, the continued use of this method is not warranted, as the same degree of precision can be

obtained more simply and rapidly by perchloric or persulphate oxidation.

Practically all the present-day plain carbon steels contain small amounts of accidental chromium from the scrap, and traces of the element can be detected in almost any steel. The estimation of such small amounts by the usual volumetric methods is not reliable, especially when less than 0·02% of this element is present. These very small percentages can be estimated with a remarkable degree of accuracy by a colorimetric method based upon the extremely sensitive colour reaction that dilute acidified chromates give with diphenyl carbazide. The colour produced is an intense violet red, possessing a fair degree of stability and is sensitive to one part of chromium in five million parts of solution. Chromium in steel can readily be obtained in a form suitable for this test by treatment with sodium peroxide, and removal of the iron by fractional filtration.

Titanium is an element which has recently assumed a much greater importance in steel-making, due to its use in some of the austenitic nickel-chromium steels of the Staybrite type, in connection with the prevention of weld decay or inter-crystalline corrosion. Many of these steels contain 0·50 to 0·60% of the element, and occasionally up to 1·0% is present. The estimation of the element in unalloyed steels is simply and accurately performed by the well-known colour test based upon the yellow colour of pertitanic acid in peroxidised sulphate solutions.

The colorimetric estimation of copper in steel is based upon the blue amine colour which copper gives in ammoniacal solutions. Copper is readily obtained in a form suitable for the test by the standard sodium thiosulphate process. The accuracy of this process with the larger amounts of copper falls below that of the well-known iodometric titration, but at the same time it is sufficient for most routine purposes. The smaller amounts of copper up to 0·60% are more accurately determined by this method than iodometrically.

New Methods for Molybdenum Estimation

Molybdenum is added to many of the nickel-chrome steels in connection with the prevention of temper brittleness. It is also an important constituent of several types of high-speed steel and rustless steels. The old standard methods—namely, the lead molybdate and molybdenum sulphide methods are still in general use, but they have been augmented during the last few years by the introduction of the alpha-benzoin oxime method and the butyl-acetate colorimetric process. These new methods each have their own particular advantages, but it is doubtful if they are superior to the lead molybdate method. The oxime method is rather lengthy in operation, owing to the bulky nature of the precipitation which retards filtration, and also to the slow rate of removal of the rather large amounts of organic matter and the necessity for a low ignition temperature. The method is, however, the most satisfactory available means of determining the element in vanadium steel, and also in the special 7% molybdenum high-speed steels.

Several excellent methods are available for the determination of the total aluminium content of steel, but the close chemical similarity of this metal with iron, chromium, titanium, and several other steel-making elements precludes the use of any one method which is not time-consuming and detailed in manipulation. The caustic soda separation is the basis of a very useful method, and one which is particularly suited to the nitrogen hardened steels which contain upwards of 1·5% aluminium. The method employs a caustic soda separation exactly similar to the well-known soda separation for molybdenum, and in fact can be used to supply an estimation of both elements.

Cobalt is an essential constituent of several grades of super high-speed steel, some of which contain upwards of 15% of the element. The actual determination even in highly alloyed steel is comparatively easy. The details have been thoroughly investigated, and do not appear to have been the subject of any recent advances of note. Choice of methods is somewht limited, the sulphide process and the naphthol process being the only two standard methods in universal use. The naphthol method is much quicker, less laborious in manipulation, and generally more satisfactory if it is not required to determine nickel and manganese simultaneously.

The traditional method for estimating arsenic in steel is the old distillation process based on the volatility of arsenic trichloride. This method is inclined to erratic results and has been quite recently superseded by a neater and more dependable method based on reduction and precipitation of arsenic in the elementary condition with hypophosphorous acid. This method is capable of great accuracy, providing precautions are taken to reduce the magnitude of the blank to a minimum value.

The recent additions of tantalum and columbium to the austenitic stainless steels has presented an urgent problem, and one so difficult of solution that at present it represents probably the most unsatisfactory feature of alloy steel analysis. So close is the chemical similarity between these sister metals that the steel chemist has great difficulty in deciding how best to tackle this pressing problem. The accuracy of the methods used is militated by the presence of titanium and tungsten. Much is being done and much remains to be done before standardised methods for these two elements can be devised approaching in accuracy and simplicity the methods available for some of the common elements.

The use of zirconium as a steelmaking element has not found more than occasional application. Small amounts are sometimes added for deoxidation purposes, but the major portion is lost in the slag as deoxidation product. Several methods for its determination are available, suitable, with modification, for all types of alloy steel, although all are somewhat lengthy and tedious in operation With the possible exception of the ether separation, the best method of separating small amounts from relatively large amounts of iron is that generally known as the phosphate method, which takes advantage of the insolubility of zirconium phosphate in moderately strong sulphuric acid solution.

Selenium is one of the very latest additions to the family of steelmaking elements. Small additions of this element to the austenitic nickel-chromium steels are reputed to confer improved free-cutting properties. The analytical chemistry of selenium has been fairly well explored in other fields, and reliable methods of estimation established prior to its use in steel, so that the early work with selenium steels was largely a question of establishing the modifications imposed by the presence of iron and associated elements, and the best means of separating and obtaining the selenium in a pure solution suitable for its estimation by existing methods. An excellent method by L. Silvermann permits the use of 5-grm. samples, and consequently leads to increased accuracy.

Beryllium is an element closely resembling aluminium which has been occasionally added to steel. This forms soluble beryllates with the caustic alkalies, and this property furnishes the best means of separating the element from iron. The separation is performed by dropwise addition of the acid beryllium solution into an excess of hot caustic soda.

New steels are constantly being made and new elements added. Elements, like cerium, at present curiosities to the steel chemist, may soon be commonplace. We are now only on the fringe of the alloy age, the possibilities are boundless, and the nature and constitution of alloys to come can only be envisaged. Perhaps the salvation of the chemist of the future will devolve upon the development of something like 90 selective reagents, one for each element, and each one a guaranteed specific for its own particular element.

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BRIGHTER BRITAIN

THERE is a growing sense of industrial and trade stability in this country. Despite a certain nerviness which has caused rapid fluctuations in market prices, all the more important industries are showing signs of progress. It is pleasing, for instance, to note that during the last few months the coal industry has enjoyed a substantial revival. Even in the cotton industry, improvement is being maintained, while the iron and steel industry, after remaining practically stationary during January and February, raised production during March to a new high level. A real measure of improvement has taken place in shipping, with the result that shipbuilding is in a healthier position than for many years past. Practically all branches of the engineering industry are experiencing great activity, while the machine-tool makers are finding increasing difficulty in coping with orders. The general upward trend is making increasing demands on the producers of raw materials, and in addition to the pressure on the iron and steel industry to satisfy requirements, there is considerable activity in the production of semi-finished manufactures of the non-ferrous metal trades.

The brighter conditions are doubtless due in the main to the increased activity in the home trade, but it is important to realise the part exports are playing in this revival. For the third month in succession, there has been an appreciable increase ; a welcome contrast to the general tendency during last year, when exports remained practically stationary. It is probable, indeed, that but for the heavy demands made on industry for the home market, exports in certain markets would be higher. As it is, however, the overseas trade returns for March reveal a substantial expansion in our foreign trade, but with this expansion there is taking place accentuation in the adverse visible balance of trade. The exports in March, for instance amounted to nearly £43·5 million, a rise of over £5 million over the previous month and £7 million over March of last year, whereas the imports at over £82·5 million have risen more steeply by £11 million over February and £14.5 million more than in March, 1936. The steady deterioration in our visible trade position is a movement which is accelerating rather rapidly, but this may be regarded as satisfactory evidence that industries are able and confident enough to buy raw materials abroad.

There are many causes for this revival, the most important being the gradual improvement in world conditions, in which practically every country is contributing. There is a growing confidence that the clouds which have hung so heavily over Europe are being gradually dispersed, and, with greater optimism, trade and industry has been given a brighter aspect. The opportunity is here for a forward movement and a return to conditions of greater freedom in international trade, but the countries are still bound by exchange controls, by rigid quota agreements, and high tariffs—effectual barriers which are preventing the more rapid adjustment of satisfactory commercial relations between the countries of the world.

Although there is considerable improvement, industry in this country cannot be regarded as established on a permanently prosperous basis until exports show a very substantial increase, and every step should be taken which is likely to bring about a further improvement in this connection. It was hoped that the currency agreement between England, France and America, to relax restrictions, would have stimulated the flow of international trade, but the results have been disappointing. The problems of currency, instability, exchange restrictions, quotas and tariffs must be considered by the governments of the various nations, and the longer the necessary readjustments are delayed the greater will be the difficulties with which all industries will have to contend in planning for the future.

In this country, as in other countries, industry is undoubtedly being stimulated with the production of armaments, but while Britain's rearmament policy shows her desire to play her part in the readjustment of power, the cost is a heavy burden. With growing confidence amongst the nations, the race in armaments should gradually cease, when they would be in a better position to attend to more peaceful occupations with a view to effecting economic recovery. Increasing world trade, despite existing barriers, does in fact indicate that the need for more peaceful occupations is appreciated and the prospects for an all-round recovery have not been better in the last ten years.

The burden of armaments will be indicated shortly when the Budget is presented and new methods shown for raising money to meet the increased expenditure. It is probable, indeed, that the Chancellor of the Exchequer will rely largely upon trade recovery prospects rather than hampering industry with further taxes. Whatever means are decided upon, it can be said that industry will in the long run have to meet the cost by increasing output and finding increased markets for their products.

Looking back to the slump conditions of 1930-2, we can regard them as abnormal conditions from which we are now emerging to more normal conditions. Even the rising tide of industrial unrest is largely due to the better times in which we are living. The long list of strikes and disputes, threatened or pending, need cause little alarm ; they can be regarded as growing pains, which in most cases will not be felt, because settlements will be reached by adjustment. The trouble at Harworth, however, is a more serious problem, and it is hoped that a reasonable and equitable solution will prevent a foolish and disastrous strike.

Despite a number of factors which tend to hinder the full realisation of a forward movement, not the least being the large number of unemployed, conditions in this country show considerable improvement over those of a year ago, and it is particularly gratifying because of the forthcoming celebrations in connection with the Coronation. It is, in fact, probably true that the brighter trade returns have been fostered to some extent by the Coronation, especially trade with the overseas Dominions, because of the desire of so many business men abroad to have an additional incentive to visit this country next month.

There can be little doubt that the British Monarchy provides a firm constitutional link between the various nations of the Commonwealth. The fabric of imperial unity is so delicate that no other effective or permanent substitute is possible. In the Dominions the attachment to the Sovereign is strong and the interest displayed in the Coronation is not less than in Britain itself ; it is not surprising, therefore, that visitors are coming to this country in large numbers, but the fact that brighter conditions are being experienced in Britain will add to the cordiality of their reception and assist them to appreciate the hospitality for which the people in these islands are noted.

OVERSEAS VISITORS

IN view of the Coronation in May, Britain will be entertaining more visitors from overseas than at any previous time in her history. From practically every foreign country, as well as near and remote places in the British Empire, the Coronation, together with the celebrations associated with it, is attracting an extraordinary number of visitors who will undoubtedly take the opportunity to see Britain, its impeccable scenery and old-world charm that still remain, and to enjoy the cordiality for which its inhabitants are noted. Facilities have been arranged or are contemplated to enable visitors to see the beauties of Britain and to enjoy its hospitality, but it is probable that a large number of visitors will desire to mix pleasure with business and will take advantage of the occasion to either renew or make new commercial contacts.

Nothing is quite so important to Britain than a progressive international trade and a growing trade with her overseas Dominions, and since conditions were never brighter for a revival of this character, the possibilities of bringing together potential buyers and manufacturers, offered by the great influx of visitors, should not be overlooked. Contacts will be made during the next few months that may well result in new business long afterwards, business that would have been very unlikely without the personal contact.

To those visitors who seek commercial introductions, the most convenient and reliable source is the Department of Overseas Trade, 35, Old Queen Street, Westminster, S.W. 1, where every assistance would be given to effect a suitable contact. To those, however, who are particularly interested in the fields covered by this journal, we direct attention to the firms represented in its advertising pages. A letter or telephone call to any of these will lead to the making of suitable arrangements. It is not anticipated that any difficulties would be presented, but should contact not be possible through these channels we shall be happy to assist overseas readers who are potential buyers of manufactures and products within our field.

Many visitors will undoubtedly take advantage of the facilities offered to visit some works in Britain, to see for themselves the production of her industries, the products from which have earned such a high reputation throughout the world for quality. From a technical point of view, visits to works can frequently be useful, since many aspects of production can be seen at first hand. Here, again, the best course is to communicate by letter with the firm whose works it is desired to visit when we are convinced that reasonable arrangements will be made. In some instances, firms have already advised us of their desire to conduct interested visitors over their works, amongst which are included the Bryan Donkin Co., Ltd., Chesterfield, mechanical and gas plant engineers; the Carborundum Co., Ltd., Trafford Park, Manchester, manufacturers of abrasive and refractory materials; the Dowson and Mason Gas Plant Co., Ltd., Alma Works, Levenshulme, Manchester, gas plant and furnace specialists; Kasenit, Ltd., Holyrood Street, Bermondsey, London, S.E. 1, electric, gas, oil, and solid fuel furnace makers and manufacturers of case-hardening compounds; Lamberton and Co., Ltd., Coatbridge, Scotland, specialists in iron and steelworks plant; W. H. A. Robertson and Co., Ltd., Lynton Works, Bedford, makers of rolling mills, continuous-wire machinery, reeling machines, shearing machines, screwing machines, and air compressors.

Several other firms have advised us of their willingness to give visitors facilities to visit their works, but that an appointment is necessary, for this reason intending visitors should, in every case, make the necessary arrangements as early as possible before their intended visit.

The tastefully decorated tea-room for visitors to Ford Works, Dagenham. The furniture, which is of chromium steel tubing, the chairs being complete with leather cushions and the tables with glass tops, was supplied by Messrs. Pel Ltd., London.

Professor H. E. T. Haultain Honoured by Canadian Mining Institute

JUST what happens to different types of rock when ground up by the impact of steel balls or tubes in the revolving mills used to reduce ores from mines, so as to enable the metallurgist to recover the largest possible proportion of their valuable metal contents, is a problem of major importance to the mining industry. What it takes to solve such problems as this is illustrated in the case of H. E. T. Haultain, Professor of Mining Engineering of Toronto University, who was presented with the Randolph Bruce Gold Medal by the Canadian Institute of Mining and Metallurgy at its annual convention recently held in Montreal.

A cosmopolitan and international background of technical and practical training which includes the study of electrical and mining engineering in London and Freiberg, practical experience in mining in Ireland, Bohemia, South Africa, the western states of the United States, British Columbia, and Ontario, followed by 28 years' occupancy of the chair of Mining Engineering at Toronto University, lies behind Professor Haultain's research and studies, the valuable results of which were recognised by this award.

In the solution of the fundamental problems connected with the fine grinding of ores, exact knowledge of what happens to these ores when passing through the mills that grind them and the ability to measure the sizes of the particles resulting from that grinding so as to be able to classify sizes as small as 10 microns, each less than one twenty-five thousandth of an inch are essential factors. To determine these factors, Professor Haultain called in the aid of such modern methods as slow-motion pictures, the use of which he combined with the invention of an instrument which measured the energy used in crushing the rock, and, further, enabled the results disclosed by the films to be accurately measured and classified for different types of ores. From this work the Professor evolved two devices—a "Superpanner" and an "Infrasizer,"—the development of the former of which alone took him 15 years to perfect. This work and these devices have led to the revision of many time-honoured theories regarding the grinding of mineral ores, and constitute a contribution to mineralogy the importance of which has been recognised by the presentation.

Bright Pickling of Copper and Brass

By E. E. HALLS

A bichromate/sulphuric pickle yields very good results where a bright and uniform appearance is desired, the observance of several precautions is stressed, and the use of aluminium pickling baskets is recommended. Loads to be treated should be economic, and the capacity of the bath employed chosen to take the baskets conveniently.

COPPER and the various brasses are subjected to pickling processes both in the form of sheet, rod, or wire stock and as components, and frequently also at intermediate stages of fabrication. The bulk of stock and components, when subjected to heat-treatment processes, is seldom produced direct from the furnace in a bright condition. Consequently some quick acting yet relatively mild pickling mixture, is required for treatment prior to passing to subsequent operations. Except in those few instances where bright annealing in bell-type furnaces is practised, work is treated in electric, coke- or gas-fired furnaces, without any real attempt to produce a neutral atmosphere. Common rolling-mill practice is to heat coils to a temperature in the neighbourhood of 600° C., and to quench them while hot in water with agitation. The sudden cooling assists in the mechanical removal of the heat-treatment scale; several successive immersions further aid in the same direction. Another means adopted is to pass the metal on a conveyer through the furnace, with a water seal at each end. Under these circumstances, the furnace becomes charged with steam, and the work is quenched as it passes through the water seal at the exit end. This reduces scaling to a minimum, but does not eliminate staining. Again, in handling pressings and other small components, electric or gas-fired furnaces are usually employed, and the work is dumped from the furnace into a water tank. This only effects partial and irregular removal of the oxide. A number of electric furnaces are in operation for producing small articles in a relatively bright condition by the maintenance of a reducing gas atmosphere. Even in this instance, however, irregularities in surface appearance exist according to the condition of the work entering the furnace, and while no black scaling is caused, copper patches and variations in brightness are inevitable. Two distinct problems therefore arise. In the first, the rolling mills are concerned with the removal of scale for the prevention of damage to the rolls on the one hand, and for the avoidance of surface imperfections by rolling-in the scale in the stock on the other. In the second, components which have to pass to further drawing operations need to have heavy scale removed for avoiding its being drawn-in or wearing tools unduly, and, further, those which come from controlled atmosphere furnaces require a light pickle for the removal of a surface film which appears in practice to have a high coefficient of friction and which promotes fracture during drawing.

Fig. 1.—Two flanged brass covers, the fabrication of which involved three drawing operations with two intermediate anneals. Specimen on left treated with bichromate type of pickle, that on right to nitric/sulphuric dip processes.

Pickling Solutions for Removal of Scales

The removal of these scales and films is commonly effected by means of a sulphuric acid pickle, either hot or cold according to local conditions. The action is appreciably more rapid without any additional pitting of the base metal when the acid solution is used hot. A concentration of sulphuric acid of 5% by volume operated short of boiling is used for brass stock, and 10% strength for copper stock under the same operating conditions. A 10% solution, when used cold, is the popular mixture for brass, but at the low temperature is very slow if heavy scale has to be removed. For treating miscellaneous small articles, which come from controlled-atmosphere furnaces, the 10% cold solution is usually employed for the removal of the surface film. For removal of any residual heavy scales after quenching from ordinary furnaces, a nitro-sulphuric mixture is quite common in preference to using a hot sulphuric acid solution. The following mixture is a popular one, and achieves the object without undue dissolution of metal or pitting, and which produces a reasonably bright article.

Sulphuric acid	60% by volume.
Nitric acid	10% „
Water	30% „

The notable shortcoming of the straight sulphuric pickle for brass is that it will not remove copper stains. Work, therefore, has an unsightly appearance. There are occasions when dealing with small objects when this is detrimental purely from an appearance viewpoint and when further dipping operations become necessary in consequence. On the other hand, in some engineering factories, the psychological aspect enters and the press shop people dislike handling work that is not bright. Bright acid dipping is frequently resorted to in these circumstances, but baths often get beyond control with detrimental results with respect to pitting and thinning of the metal. To meet these latter objections, a sulphuric acid/bichromate mixture can be effectively employed. The make-up of the bath is as follows:—

Sulphuric acid content	5% by volume.
Potassium bichromate	3% by weight.

It is operated cold, and yields with brass a pleasing appearance, bright without lustre, by virtue of its golden-yellow colour.

Where rolling mills have to deal with soft material which cannot be brightened to a uniform tint by a subsequent cold rolling, copper-stained material is conditioned in a pickle of this bichromate type. Copper itself also responds

favourably, leaving the solution with a pleasing, natural copper colour.

Potassium bichromate is a strong oxidising agent, and reacts readily with materials of a carbonaceous nature. Consequently, contamination of the pickling bath with greasy and oily substances, or sooty matter and extraneous dirt, should be scrupulously avoided. Actually, no difficulty should be encountered in this because work arriving direct from heat-treatment should naturally be quite free from such objectionable constituents. Here again, it is assumed that the work will have been degreased prior to annealing, a natural precaution to take.

Dipping Baskets

Another point of interest concerns the dipping baskets or work containers when using a sulphuric/bichromate pickle. The latter is particularly active in removing copper stains, and will therefore also attack copper baskets more rapidly than does a straight sulphuric acid pickle. Likewise, if brass baskets are employed, they relatively rapidly become destroyed by virtue of the selective dissolution of the copper constituent. On the other hand, it is found that aluminium containers give the best service and dissolve away appreciably less readily than any of the other metals

TABLE I.

RESISTANCE OF METALS TO PICKLING SOLUTIONS.

10% Sulphuric Acid (v/v) Room Temperature, 20° C.

—	Area, In.	Original Weight, Grms.	Loss in Grms. after 6 Hours' Immersion.	Loss in Grms. after 22 Hours' Immersion.	Total Loss, %.	Original Thickness, Mils.	Thickness in Mils. after 22 Hours' Immersion.
Aluminium	3 × 2	10·85	0·0070	0·0206	0·18	41	41
Copper	,,	9·16	0·0056	0·0234	0·25	12	12
Brass	,,	13·62	0·0054	0·0132	0·13	17	17
Monel metal	,,	16·78	0·0053	0·0121	0·075	20	20

TABLE II.

RESISTANCE OF METALS TO PICKLING SOLUTIONS.

5% Sulphuric Acid (v/v) and 3% Potassium Dichromate (w/v) Room Temperature, 20° C.

—	Area, In.	Original Weight, Grms.	Loss in Grms. after 6 Hours' Immersion.	Loss in Grms. after 22 Hours' Immersion.	Total Loss, %.	Original Thickness, Mils.	Thickness in Mils. after 22 Hours' Immersion.
Aluminium	3 × 2	10·91	0·0209	0·0600	0·55	41	41
Copper	,,	9·10	3·25	3·67	41·6	12	8
Brass	,,	13·59	3·27	3·81	28·0	17	12
Monel metal	,,	17·19	2·77	3·50	20·4	20	18

that would normally be used. In this connection, some pertinent data are presented in Tables I. and II. That in Table I. appertains to the straight sulphuric acid pickle employed cold. Aluminium copper, brass, and Monel metal test-pieces immersed in the acid solution were weighed and measured in thickness before and after periods of 6 and 22 hours. The weight losses are very small, but progressive, while the thickness diminution is not determinable by ordinary micrometer measurement. Monel metal shows up to advantage as compared with the other metals. Table II. appertains to the 5% sulphuric acid pickle, containing 3% of potassium bichromate, operated cold. Similar readings are given to those in the first table. All the weight losses are greater, but considering the 6-hour immersion time, while the loss on the aluminium is still of negligible order, it has increased to that of the 22-hour period in the first case. The copper and brass losses have become enormous, and when considered in relation to the losses in 22 hours, show that these two metals have apparently exhausted all the available bichromate. Likewise, the loss in weight of the Monel metal specimen is exceedingly high, although it shows up better than the previous two. This metal, too, apparently exhausted the bichromate well before the expiration of the 22-hour period. These changes are confirmed by the reduction in thickness determinations—the aluminium for all practical purposes is unchanged, the brass and copper approximately 30% thinner, and the Monel metal about 10% reduced.

An instance was brought to the writer's notice where copper and brass baskets had been tried. The information given in this connection was that the use of copper baskets rapidly caused the solution to deteriorate due to decomposition of the potassium bichromate, while the baskets themselves quickly became thinner, distorted easily and broke across the perforations within a few days. The brass proved a little superior with respect to the deterioration of the solution, but weakened mechanically just as rapidly as the copper ones. The substitution of the aluminium baskets was recommended, and since their use, normal life has been obtained from the solution, and although the baskets have been in active usage for twelve months, they are still mechanically sound. Thus, the practical findings confirm the main features demonstrated by the laboratory tests.

Bichromate Type of Pickle

In a general engineering works, one important advantage of the bichromate type of pickle is the fact that it yields a clean, golden-yellow, uniform finish. It commands, therefore, a greater cleanliness in tools and more ready visual appreciation of any defects in forming or drawing operations. As contrasted with the vigorous, uncontrolled bright-acid dip, it yields a smooth, less pitted surface, which is a great advantage when a number of such treatments are necessitated by a sequence of anneals, as well as being reflected in the quality of any final electroplate or

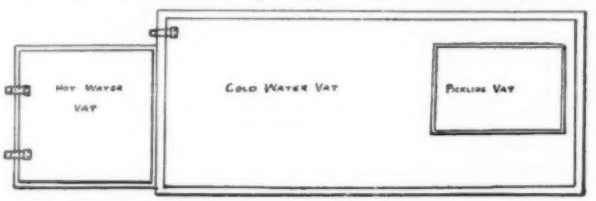


Fig. 2.—Typical arrangement of pickling bath and wash water.

enamel finish. Some appreciation of the minimum difference in surface smoothness due to the extent of pitting or etching can be gathered from Fig. 1. The illustration depicts two flanged brass covers, the fabrication of which involved three drawing operations with two intermediate anneals. The latter were effected in an open gas furnace, followed by quenching, and produced the normal extent of scaling. Specimen A represents work treated with the bichromate type of pickle, and B work subjected to nitric sulphuric acid dip processes. The difference in smoothness is apparent, but was even more pronounced in the actual specimens than is reproduced in the photographs. With work from controlled-atmosphere furnaces, entire smoothness is secured.

Conclusions

In conclusion, it is contended that where something brighter and more uniform in appearance is required than is provided by sulphuric acid pickles, and with the avoidance of the pitting usually associated with vigorous nitric acid containing dips, the bichromate/sulphuric pickle provides a useful medium. The latter yields very good results, but, if to be retained within economic bounds, the observance of several precautions is necessary. The use of aluminium baskets is recommended, organic matter must be rigorously excluded, and immersion time should be maintained at a minimum consistent with producing the desired result. Excessive immersion times consume an unnecessarily large quantity of the bichromate, although without any deleterious effect on the thickness or appearance of the work. Loads to be treated should be economic, and the capacity of the bath employed chosen to take the baskets conveniently without a superfluous excess of unoccupied space. Again, it is advantageous to employ a relatively deep pickling vat, with the solution level about one-third from the top, to facilitate draining of baskets back into the pickle. The pickling tank proper, if situated inside a large tank of flowing cold water, and towards the back of it,

(*Continued on page* 181.)

Cold-rolling Strip Metal

The use of strip metal is primarily for press work and, as the scope of press work is developing very rapidly, strip rolling is increasing in importance, the design of mills for this purpose therefore has been a subject of much study. In this article reference is made to some recent work on the subject.

STRIP metal may be regarded as metal which can be coiled in long lengths, and is distinct from sheet metal, which is rolled flat and in short lengths. According to Hoff[1] the cold rolling of strip was first carried out in the middle of the past century in Hohenlinburg in Westphalia. The method was developed up to the end of the century mainly in small works, and soon it became clear that strip was suitable for displacing sheet. It is possible to adapt the width of the strip to all demands. Strip has great advantages over the sheet, when further processing, such as pressing or drawing, is necessary as, for instance, in diminishing the scrap and enabling the use of automatic machines.

Types of Cold-rolling Mills

The construction of cold-rolling mills has been greatly influenced by the continuous increase in the reduction of thickness per pass and especially in the width of the strip, since the rolling pressure increases proportionally, and the diameter of the rolls also must be enlarged proportionally. This is generally done, but suitable means have been sought to make the diameters of the working rolls as small as possible and supporting rolls have been used. The working rolls of small diameter were first supported by those of big diameter in the three-high rolling mill of Lauth, but also at different times in reversing plate-rolling mills. Two or more supporting rolls are applied in cold-rolling mills; the greatest number (up to 20) being used by W. Rohn in Hanau, who has made a plea for rolls of very small diameter

TABLE I.

Pressed Length of Strips and Plates of a Thickness of 0·0787 in. (2 mm.) Depending on the Diameter of the Rolls and on the Reduction per Pass.

Diameter of the Rolls.	Pressed Length in Inches (mms.) at a Reduction per Pass in Inches (mms.).				
—	0·0078 (0·2)	0·0157 (0·4)	0·0236 (0·6)	0·0314 (0·8)	0·0393 (1·0)
0·787 (20)	0·0555 (1·141)	0·0787 (2·00)	0·096 (2·44)	0·111 (2·82)	0·1245 (3·16)
1·574 (4·0)	0·0787 (2·00)	0·111 (2·82)	0·1363 (3·46)	0·1574 (4·00)	0·176 (4·47)
3·15 (80)	0·111 (2·82)	0·1574 (4·00)	0·1925 (4·89)	0·2226 (5·65)	0·249 (6·32)
3·93 (100)	0·1245 (3·16)	0·176 (4·47)	0·2153 (5·47)	0·249 (6·32)	0·2783 (7·07)
5·9 (150)	0·1524 (3·87)	0·2153 (5·47)	0·2638 (6·70)	0·3047 (7·74)	0·341 (8·66)
11·81 (300)	0·2153 (5·47)	0·3047 (7·74)	0·3732 (9·48)	0·431 (10·95)	0·481 (12·24)
23·62 (600)	0·3047 (7·74)	0·431 (10·95)	0·530 (13·44)	0·610 (15·49)	0·682 (17·32

The advantages of small diameter rolls have been recognised for a long time, but realised in practice very rarely, although they are discussed in detail in literature. The pressed length and consequently the pressed area of the rolled material depends on the diameter of the rolls and on the reduction per pass. The effect is shown in the example, Table I, which gives English measurements and their metric equivalent.

1 (Professor H. Hoff VDI Zeitschrift des Vereines deutscher Ingeieure Vol. 80 Nr. 46 pp. 1387/88).

The greater the press length, the greater is the leverage of the increased rolling pressure; to this must be added the unequal distribution of pressure in the clearance of the rolls. The rolling pressure increases from both sides to the interior of the rolled material, and the increase is greater the longer the clearance—*i.e.*, the pressed length Thus the working conditions are favourable to the use of smaller diameter working rolls, but consideration must be given to the fact that the rolls must grip the material and draw it through. Because the movement of the rolled material, in relation to the surface of the rolls, is the smaller the shorter the clearance of the rolls, the wear and tear of the rolls and the development of heat will decrease in a certain proportion. These considerations are confirmed completely be recent experiments of Lineg and Pomp, to which reference is made later in this article. Here it may only be mentioned that the resistance to deformation increases with the diameter of the rolls. This increase is to be accounted for by the augmenting of the forces of friction or to the resistance against flow in the material, if the length of the clearance of the rolls increases. Thus, also, the efficiency of the deformation is more favourable the smaller the diameter of the rolls.

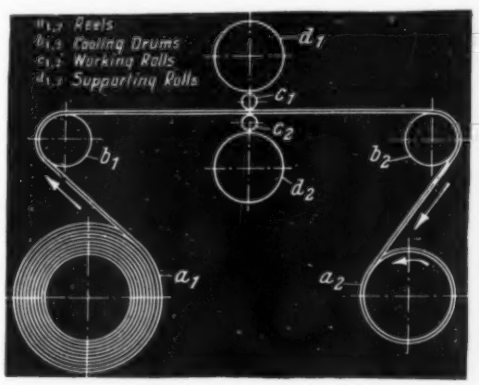


Fig. 1.—Cold-rolling mill for strip by Steckel.

Deflection of the Rolls

The decrease of the diameter of the rolls is limited in simple two-high rolling mills, because the rolls would be deflected too much if the diameters were too small. The consequence would be that the strips would have unequal thickness and undulating edges. The smallest deflections have to be taken into account by crowning the rolls. Crowned rolls, however, can only produce a faultless strip if the rolling pressure is just sufficient to make the working surfaces of the rolls exactly straight and parallel to each other. As the rolling pressure is also influenced by the reduction per pass, and by the quality of the rolled material, these rolls can be only used for the same reduction and the same material. It is better, therefore, to work with rolls which cannot be deflected, which can be attained by using strong enough supporting rolls.

Supporting rolls have no drive, but must be borne in such a manner that they rotate by friction on the working rolls; for this purpose roller bearings are employed. Thus it is possible to make the diameter of the working rolls so small that the journals are just strong enough to transfer the necessary torque, the supporting rolls having a diameter large enough to prevent deflection of the working rolls vertically to the longitudinal axis, but forces, working in the rolling direction, may deflect the working rolls of small

diameter in this direction and two different types of rolling mills are manufactured in order to overcome this difficulty. In one type the longitudinal axis of the working rolls is set back some millimetres, opposite to the rolling direction, against the longitudinal axis of the supporting rolls, thus also supporting the working rolls in this direction. In the other type each working roll has two supporting rolls. This type has the advantage of dispensing with the need for a special journal bearing for the working rolls, but the disadvantage is that room for the supporting rolls, and therefore their diameters, is limited. This disadvantage is avoided at the rolling mill of Rohn.

The diameter of the working rolls is determined by the diameters of the coupling journals in rolling mills with supporting rolls. These coupling journals, however, have to transfer the necessary torque. Different experiments have been made to increase the initial tension of the emerging strip so far that a considerable part of the rolling work has to be done by the drive of the reel. This arrangement puts very high demands on the regulating arrangement of the driving motors of reels and rolls. The results of these experiments are obviously not satisfactory. In comparison, the rolling mill of Steckel (see Fig. 1) has met with widespread use in America ; in this type the reels are driven and the working rolls operate as drag rolls, thus the strips themselves have to transfer the forces necessary for the deformation, and the reduction pass is necessarily limited, but the rolling speed can be greatly increased.

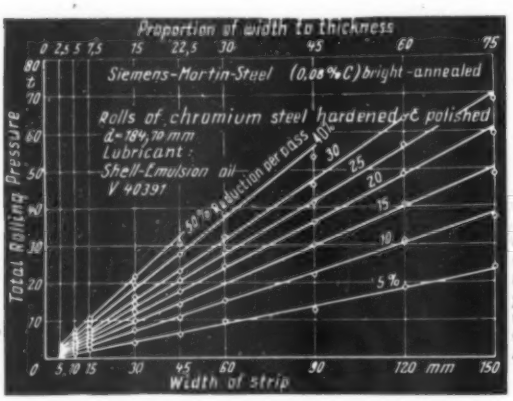


Fig. 2.—Influence of the width on the rolling pressure in the cold rolling of steel strip.

There is no doubt that the trend of future development in cold-rolling practice is to use machines with working rolls of a diameter as small as possible, but more experience must be available before it can be decided if preference should be given to the Rohn or Steckel type of mill.

Some rolling experiments have been carried out by W. Lueg and A. Pomp,[2] which give information on the influence of the material to be rolled, the rolling speed, the width of the strips and previous cold deformation on the rolling process.

Arrangement of Experiments

A roll-housing was used, into which could be fitted rolls of hardened chrome-steel of a diameter of 6·3 in. (160 mm.) and a face length of 7·867 in. (200 mm.) or chilled rolls of the same dimensions. The latter, with a Shore hardness of 85, ran in plain bearings and the chrome-steel rolls, with a Shore hardness of 100, had roller bearings. Bright annealed, sharp-edged strips of 1·181 in. × 0·0787 in. section (30 × 2 mm.) were used as the material to be rolled.

The rolling pressure was measured as the sum of the pressures between the pressure mandril and the bearings of the upper roll, by means of a hydraulic measuring apparatus. The average resistance against deformation acting on the unit of the pressed area between roll and material to be rolled can be determined by the dimensions of the material before and after the experiment and by the rolling pressure.

2 W. Lueg and A. Pomp Mitteilungen des Kaiser Wilhelm Institut fur Eisenforschung, Dusseldorf Vol. 17 Nr. 20 1935. W. Lueg Zeitschrift des Vereines deutscher Ingenieure Vol. 80 Nr. 36. 5th September, 1936).

Further the relative difference between the peripheral speed of the rolls and the speed of the emerging material was determined by the impression of marks which had been fixed to the rolls and drawn on the material. This distance, called "forward slip," is a comparative measure of the conditions of friction in the clearance between the rolls. If the material had been greased with an emulsion oil, it was rolled only once through the rolls. The reductions per pass were distributed as equally as possible over a range of 5–50% decrease of thickness.

Results of the Experiments

A detectable influence of the material of the rolls on the rolling process could not be established. Experiments with variable speed of the rolls from 0·26 r.p.m. to 36 r.p.m., *i.e.*, in a proportion of 1–140, gave a similar result.

Strips of width of 0·1968–5·9 in. (5–150 mm.) of the same material were rolled for determining the influence of width. As shown in Fig. 2 the rolling pressure for all reductions per pass increased rectilinearly with the width of strip. The straight line for a reduction of 50% goes through the zero-point. At this reduction the rolling pressure per unit of the pressed area between roll and material is not further influenced by the width of the strip. At smaller reductions the curves are deflected downwards near to the zero-point which could not be shown in the illustration. The increase of the width is the greatest for widths of strips of 0·3937–0·59 in. (10–15 mm.) ; then it decreases again and there is no further change at widths of more than 1·771 in. (45 mm.)—*i.e.*, the influence of the width of the strip on the rolling process disappears at widths which are large in proportion to their thickness.

The influence of a previous cold deformation is also determined for rolling strips of 1·181 in. × 0·0787 in. section (30 × 2 mm.). The strips were rolled previously so that test bars of equal dimensions resulted, which had degrees of previous rolling of 0–40%. These test bars were like strips of a material of higher strength with regard to rolling pressure and forward slip.

Moreover from the behaviour of these figures the reduction per pass can be determined at which the rolls have been flattened noticeably. The influence of the degree of previous rolling on the average resistance against deformation is characterised in the range of reduction of 20–40% by an increase of the resistance against deformation at least twice as great as the degree of previous rolling. For instance, if this degree be 20%, the resistance increases at least 40%. It could be taken, from tensile tests of the bars of this range of experiments, that it is without practical significance whether the whole deformation is done in one or several steps.

The Royal Aeronautical Society

On Monday, April 26, 1937, the President, Mr. H. E. Wimperis, C.B., C.B.E., M.A., M.I.E.E., F.R.Ae.S., will deliver his presidential address to the Royal Aeronautical Society, in the Lecture Hall of the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C. 2. The lecture will begin at 8 p.m.

The main part of his address will be concerned with a statement of the problem of human flight as related to the laws of nature, to which, like all else, it has to conform. One of the aspects of this problem is the relationship of those laws to the construction and performance of the airplane and its engine, the other is the physiological factors which limit the endurance of the human body, whether that of the pilot or his passengers. The President will endeavour to forecast in the light of present knowledge the limits thus imposed in respect of human flight.

The lecture will be followed by two films, one showing the humming bird in flight and the other the pelican, both at natural speed and in slow motion. The humming bird film, which was first shown at the Conversazione, is being shown again by special request. The pelican film will be shown for the first time to members at the meeting.

The Heat-treatment of Structural Steel

Some General Observations

By LOXLEY

Heat-treatment is a vital operation in the fabrication of most metal parts which are required to possess certain specified properties. Often the changes brought about by the operation involve changes in the constitution of the metal, by altering the nature, form, size, or even the actual distribution of the components of the metal structure. In this article the author confines his attention to the heat-treatment of structural steel, and presents some general observations to be followed in a subsequent article giving some practical points.

In a broad sense, the term heat-treatment includes all thermal processes that affect the physical or mechanical properties of metals and alloys. Together with winning and alloying, and fashioning to shape, it completes the tale of metallurgical endeavour. As Professor Albert Portevin[1] has said, "The study of thermal treatment is often of even more practical importance than the search for new alloys; besides, the useful effect of the addition of new elements is generally entirely dependent on a thermal treatment, without which the result would be of little interest."

Steel no longer has the distinction of being the only alloy capable of improvement by quenching, and tempering, and age-hardening. Duralumin and many other alloys that respond similarly to heat-treatment have been discovered; but steel still occupies a pre-eminent place in the large group of alloys capable of improvement by quenching and tempering. Take away these heat-treatable non-ferrous alloys and general industrial progress would not have been seriously affected. Certain branches of engineering might not have advanced quite so quickly as they have done, but, on the whole, the loss would not have been serious. But take away the split Al transformation in steel and the formation of martensite, and the whole fabric of present industrial development would certainly have been delayed to an extent that it is difficult to imagine.

The iron-carbon equilibrium diagram contains the broad principles on which the heat-treatment of structural steels is based. This diagram and these principles have been enunciated so carefully, so often, and in so many places, it seems hardly necessary to attempt it again here. It is true that the diagram has changed a little in minor details since many of us were introduced to it, but these changes are not of importance in the art of heat-treating structural steels. The diagram is an excellent guide, but it should not be allowed to become an obsession. In practice, it is better to disregard theoretical considerations to a certain extent and select for use as few ranges of hardening temperatures as possible. The fewer the number of treatments in use the less chance there is for mistakes to be made, and the greater the general convenience in the shop. This advice may not be theoretically sound, but it is good sound practice.

The iron-carbon equilibrium diagram may tell most of what is required for the selection of hardening temperatures, but it does not tell us anything about hardening, quenching curves, and a knowledge of critical quenching speeds do. The first essential in successful heat-treatment is to get the steel hard, as every practical heat-treater knows, to put it into the martensitic condition. After all the patient researches that have been made, and the wordy battles that have been fought about the nature of martensite, the question still remains unsettled. Thanks to the work of many investigators, we know quite a lot about what happens when steel is quenched, and why different steels and various quenching media behave in different ways. The essential thing is to hurry the steel through the temperature range (immediately below the normal Ar1 change-point) between approximately 650° C. and 400° C., as well as starting the quench energetically. Below this temperature range cooling may be relatively much slower, and for some special steels it may be very slow, without causing loss of hardness.

The formation of troostite is the cause of most unsatisfactory hardening. It now seems certain that troostite and martensite are both formed directly from austenite and that martensite is not an intermediate product between austenite and troostite. It has also been shown that martensite does not form until quite low temperatures have been reached (below 300° C.), and the austenite must, therefore, be kept unchanged until the steel is not greatly above room temperature if it is to transform into martensite as completely as possible. If the rate of cooling is too slow, the austenite transforms directly into troostite, more or less, according to the type of steel and the rate of cooling, and it does this most energetically at about 600° C.

From what has been said, it will have been realised that there may be a difference between the dark etching constituent formed on quenching and the dark etching constituent formed during the early stages of tempering a hardened steel—that is, troostite formed on cooling is an aggregate of cementite and ferrite. The constituents exist as laminæ barely discernible under the microscope when using the highest magnification at present available; in the troostite formed during tempering the cementite is in the form of spheroids. As might be anticipated, they differ in some of their other physical properties, their response to cold work, for example, is one that is of practical importance in the drawing of wire.

Inherent Grain Size

In writing of the heat-treatment of steel at the present time, it is scarcely possible to refrain from some reference to inherent grain size. Consciously or unconsciously, the heat-treater has always aimed at controlling the grain size of steel. In general, small crystal grains are desired, an object directly attained by the normalising or annealing of castings and forgings, and incidental to heat-treatment by quenching and tempering. That is the established use of the words "grain size" in reference to coarse and fine-grained steels, but latterly the term has been much used without qualification in another sense. It is important to distinguish between "grain size" and "controlled grain size," or better still, "inherent grain size." These are rather unwieldly terms, but, if confusion is to be avoided, better than giving the simpler "grain size" two jobs to do.

The steelmaker fixes the inherent grain size by the way in which he finishes the steel, and once the liquid steel has set in the ingot mould its inherent grain size is settled. The deliberate use of steel with controlled inherent grain size has not up to the present time received much attention in this country, but as it may be of some importance in the future it seems advisable briefly to review the subject.

The present interest in such steels may be said to have started with the work of McQuaid and Ehn [2, 3] on what

1 Albert Portevin. "The Phenomena of Quenching and Tempering in Alloys," *J.I.M.* 1933. Vol. 51, p. 315.

2 H. W. McQuaid and E. W. Ehn. "The Effect of Quality of Steel on Case-carburising Results." *T.A.I.M.M.E.* 1922. Vol. 67, p. 341.

3 E. W. Ehn. "The Influence of Dissolved Oxides on Carburising and Hardening Qualities of Steel." *J.I.S.I.* Vol. 105, p. 157.

they termed normal and abnormal steels. Following their work, many investigations were made on the relationship between the steelmaking conditions and the subsequent behaviour of the finished steel during forging, heat-treating, case-hardening, machining, and so on. A recent paper by Swinden and Bolsover[4] comes as a timely addition ; it is, indeed, the first paper from English metallurgists recording the results of original work done in this country.

The terms, " inherent fine grain " and " inherent coarse grain," refer to the size of the austenite formed on reheating. The austenite of the former resists grain growth on heating, whilst the latter coarsens rather readily ; but the grains of the fine variety can be made equal in size to the coarse if the steel is taken to a high enough temperature. The terms are therefore relative only.

The alleged differences between inherently fine and coarse-grained steels that are otherwise similar may be summarised as follows : Coarse-grained steel tends to machine more easily, to harden deeper, to distort and crack more easily during quenching, and to have a lower impact value than the fine-grained variety. Lately, it has been shown[4] that fine-grained steel seems to be less susceptible to temper brittleness, and the effect of tempering in the range of temperature 250° C.–450° C.

It will be a pity if we allow ourselves to be led away by the enthusiasm of others without first examining the question for ourselves. There are many problems that need clearing up, and statements and experiments that need verifying. The alleged machining superiority of coarse-grained steels rests on a somewhat doubtful foundation ; all coarse-grained steels most certainly do not machine more readily than the fine-grained varieties. The point about shallow and deep hardening is not of the same importance in the heat-treatment of structural steels as it is in the treatment of tool steel ; it does, however, appear to be of significance in the quenching of thin sections of medium carbon structural steel. But anyone responsible for the heat-treatment of structural steel components of large cross-section will do well to inquire carefully (before demanding it) if a fine-grained steel is really what he needs. More evidence seems to be needed, too, before it will be possible to be dogmatic about the relationship between inherent grain size and distortion.

There are other and less obvious things to be considered. For example : Does inherent grain size affect damping of vibrations ? And if so, of what importance is this if the component is subject to vibration and fatigue in service ? Borphy[5] has stated that inherently fine-grained steels have a lower damping capacity than coarse. One thing is certain, however, properly made fine-grained steels have a great future for case-hardening.

Quenching Media

Successful heat-treatment depends in no small measure on the selection of a quenching medium. The more usual quenching media, arranged in decreasing hardening power, are aqueous solutions of sodium hydroxide, brine, water, oil, and air. Hot solutions of caustic soda and brine have been suggested for quenching steel that requires a cooling rate quicker than oil, but slower than water. Apart from having to provide some means to keep the solutions within the required range of temperature, their use seems to be objectionable on other grounds. Hot brine would be distinctly corrosive to the usual equipment and hot caustic-soda solution might cause injury to the workmen. Emulsions of oil and water, and soap solutions, have also been proposed as liquids having an intermediate speed of quenching. Such fancy quenching solutions are not usually very satisfactory.

Cold brine and cold caustic-soda solution have a much quicker quenching rate than water at the same temperature ; in addition to giving deeper hardening, their use helps to prevent the formation of soft spots (particularly on case-hardened components). When moderately heated, these quenching solutions do not lose their quenching efficiency as quickly as water does, for this reason they may prove of service in plants where it is difficult to maintain an adequate flow of cold water.

Some Factors Affecting Hardening

With a few exceptions, it is of the utmost importance in the heat-treatment of structural steels first, to obtain, if possible, complete hardness throughout. Just the opposite of what is often required from a high-carbon tool steel. To do this, the velocity of cooling at the centre of the piece must not be slower than the critical cooling rate of the steel being quenched. The rate at which the centre of a piece of steel can be cooled depends on the ratio of surface area to volume. The greater the mass, the slower the cooling velocity and the lower the critical cooling rate of the steel must be if it is to harden completely.

Increasing the initial temperature of the steel will give a quicker rate of cooling through the critical range of temperature for light sections, but will not be very effective for large pieces. The more drastic the quenching liquid, the deeper the hardening will penetrate, and the greater the danger of cracks developing from surface defects or internal stresses.

Quenching will be retarded if the hot steel is enveloped in a layer of steam from the water or gas from vapourised or cracked oil. Contact between the steel and the quenching liquid can be secured, at least partly, by keeping the steel moving and the quenching liquid circulating. Brine and caustic soda are more drastic in their quenching action than water. In some way the effect of the dissolved salts is to create intense turbulence at the metal surface, blowing away the water vapour and scale and ensuring a true metal-liquid interface. The efficacy of water-spray quenching is probably due to a similar cause, effected in this instance by the pressure of the water.

Changes Necessary

On many occasions in the past it has been said that the art of heat-treating steel did not keep pace with the science of heat-treatment, and that results produced in the shop often fell short of the standard that had been shown to be possible in the laboratory. The justice of such charges is less apparent to-day, the number of the offenders seems to be less, and it certainly should be. After all, if one excludes defects caused by imperfections in the material and certain anomalies caused by factors not within the control of the heat-treatment shop personnel, correct heat-treatment (meaning for the moment the attainment of the desired mechanical properties) depends on the rigid control of a few simple operations.

Given furnaces capable of maintaining any desired temperature throughout the working space, apparatus for accurately recording the temperature, and properly controlled quenching tanks of suitable volume, there is no reason why unskilled labour should not produce entirely satisfactory work ; but instructions for a predetermined sequence of operations must be carefully followed. These remarks are not intended to be indicative of the best type of labour for the job, far from it ; but they are intended to emphasise that most faulty heat-treatment (in the present sense) can be traced to wrong directions having been given, or to wilful neglect to follow correct working directions.

There is, however, another aspect of heat-treatment that is often of equal importance, particularly in an engineering works. The treatment of finished or semi-finished parts in such a way that whilst retaining the optimum mechanical properties dimensional accuracy is not sacrificed. There is a vast difference between the precautions necessary at a stamp shop engaged in heat-treating rough drop forgings and at a works where for some special reason the material has been machined to size, or at best has only a few thousandths of an inch left for final rectification.

4 T. Swinden and G. R. Bolsover. " Controlled Grain Size in Steel." *J.I.S.I.* Vol. 134, p. 457.

5 G. R. Borphy. " Damping Capacity : A Factor in Fatigue." *A.S.M.* 1935. Reprint.

The average heat-treatment shop seems to be at a decided disadvantage if it is compared with, say, the machine shops of the same works. Reflect for a moment on the money that is lavished on machine tools and the meticulous pains taken to ensure accuracy, and then consider whether the same spirit has been allowed full play when designing and equipping the heat-treatment department. Comparison is said to be odious, but it is sometimes salutary to reflect on the odious.

The methods of production engineers have done great things for the engineering industry, and lessons to be learnt from these methods should be applied to the foundry and the heat-treatment shop. In many instances the space allotted and the equipment available would be quite inadequate for any considerable modification from existing practice. New wine in old bottles, you know, is often dangerous.

Anodic Coating of Magnesium Alloys

Magnesium may be anodised in a bath of sodium phosphate and sodium dichromate. The film obtained combines both corrosion-resistance and paint-holding properties, without serious change of dimensions of the treated piece, even on machined surfaces.

MAGNESIUM alloys, because of their low density and relatively high strength and ductility, have many advantages for use in aircraft. Noteworthy disadvantages, however, are their marked susceptibility to corrosive attack under saline conditions and the low degree of adherence of protective coatings to their surfaces. Numerous attempts have been made to improve their behaviour by treating the surface so as to produce a protective film. The remarkable success attained with the anodic oxidation or so-called "anodising" of aluminium and its alloys prompted attempts to develop a similar treatment for magnesium, even though previous efforts to develop a satisfactory electrolytic treatment had not been very successful. A process recently perfected is described by R. W. Buzzard and J. H. Wilson,* which combines in a large measure the advantages of the chrome-pickle and the alkaline chromate treatments. Numerous experiments led to the selection of a bath containing about 10% of sodium dichromate ($Na_2Cr_2O.\ 2H_7O$), and 2 to 5% of mono-$_2$ sodium phosphate ($NaH_2PO_4.\ H_2O$).

All parts must be carefully cleaned before being anodised. Electrolytic cleaning has been found very satisfactory. For example, the specimen is made the cathode for at least 3 mins at 90° C. (194° F.) in a bath containing: Sodium carbonate (soda ash) (Na_2CO_3), 4 oz./gal. (30 g./liter); trisodium phosphate ($Na_3PO_4.\ 12\ H_2O$), 4 oz./gal. (30 g./liter). A sufficient potential (usually 4 to 6 volts) is applied to produce a vigorous evolution of hydrogen around the specimen being cleaned. Steel plates are used as anodes.

The cleaned metal is then made the anode in the anodising bath, in which the cathode is steel and a sufficient voltage is applied to produce a current density of 5 to 10 amperes per sq. ft. of anode surface. The time necessary to produce a satisfactory coating is dependent on the composition of the alloy, the temperature of the bath, and the current density used; at 50° C. it varies between 30 and 60 mins.

Satisfactory results with most of the commercial alloys of magnesium have been obtained in this laboratory with a bath of the above composition, operated over a wide range of temperature and of current density. The permissible maximum current density is limited by the occurrence of pitting on the anode. As might be expected, as the current density is increased, the time required to produce a good coating is lowered considerably. Satisfactory surface films have been obtained on an alloy of the magnesium-aluminium class (4·0% Al and 0·3% Mn) with current densities from 5 to 100 amperes per sq. ft., and with temperatures from 30° to 80° C. (86° to 176° F.). The favourable conditions are more restricted for alloys of the magnesium-manganese type. A lower current density, preferably less than 10 amperes per sq. ft., was found necessary with an alloy having the nominal composition of 1·5% Mn and 98·5% Mg.

A satisfactory coating is smooth and adherent, and does not flake on a sheet when bent at an angle of 90°. The colour varies with the composition of the alloy treated, from a dirty green to a shiny black. The higher the aluminium content of the alloy, the darker is the film.

Bath Control

Satisfactory operation of this bath depends on the maintenance of proper hydrogen-ion concentration (pH). For the phosphate-dichromate bath described above, the pH should be maintained between 4·0 and 4·8. During operation of the bath, magnesium is dissolved and the pH rises. Phosphoric acid must then be added to restore the initial pH. A glass electrode has been found most satisfactory for measuring the pH.

Magnesium phosphate is only sparingly soluble in the phosphate-dichromate solution. As magnesium dissolves during the use of the bath, the saturation point of magnesium phosphate is reached, and a precipitate of this substance forms, which removes phosphate ion from the bath. The addition of the amount of phosphoric acid required to maintain the desired pH of the solution is not usually sufficient to maintain the necessary concentration of the phosphate ion. Additional sodium phosphate, in amounts determined by analysis of the bath, must therefore be added. The dichromate concentration changes very slowly with use, and an occasional analysis will indicate when more dichromate is necessary.

Properties of Anodic Film

Corrosion tests by the salt-spray method have shown the anodic films to be equal in corrosion resistance to the surface coatings produced by chemical treatment. The method used was to determine the change in tensile properties, especially elongation, of strips of sheet material that were machined to tensile-bar dimensions after exposure to the salt-spray test. Salt-spray tests were made with a 20% solution of NaCl at 35° C., on a magnesium alloy (4·0 Al, 0·3 Mn), in sheet form 0·060 in. thick and having an average initial elongation of 12·4%. Exposure to salt spray for five days caused a loss of 63% in elongation on specimens that had been given the chrome-pickle treatment, and of 44% on anodised specimens. The chrome-pickle treatment was carried out in a fresh solution to assure the production of a film of the best quality.

* *Jour. Research*, Nat. Bureau of Standards, Vol. 18, Research Paper 964.

Bright Pickling of Copper and Brass

(*Contd. from page* 176.)

enables transfer to the wash water without splashing of shop flooring or of the operator. Alongside can be a hot water tank for final rinsing and drying off. Both water tanks should be provided with ample flow. A typical arrangement is shown in Fig. 2. In effect, all that is required in these precautions is only that degree of planning and attention that is demanded of normal good practice in any dipping or pickling processes. The demand for minimum immersion period is met by the rapid action of the solution, and in conformity with the rapid flow required for modern continuous production methods.

Correspondence

HEAT-TREATMENT

The Editor, Metallurgia.

Sir,—I have read with great interest your leader in the March issue of Metallurgia on the subject of heat-treatment, and also the contribution of your correspondent. May I, in the capacity of a consultant, give my views of the case as one who sees both sides—that of the steel producer responsible for producing correctly heat-treated components, and also that of the user, responsible for ordering such components.

In the first place, your correspondent appears to seek for a solution of his difficulties in the experiences of others, who have also had difficulties, and probably overcome them. This is a reasonable thing to do, but I submit that it will not prevent more difficulties of an equally serious and worrying nature. He is quite correct in stating that generalisations, tabulations and theory are perfectly adequate for components made to rigid specifications, but break down when those specifications lose their rigidity. In other words, the metallurgist, the steelmaker and the test-house can all do their part providing they are allowed to work to the heat-treatment technique which has been proved by experience. Why, then, do difficulties arise? Your correspondent strikes at the root of the matter when he states: "It may be that such a component was born out of dimensional necessity, and consequently was metallurgically cursed from its birth," only he does not suggest any remedy for such a state of affairs. Perhaps an instance from experience will serve to illustrate to what I am leading. Some little time ago a certain firm of constructional engineers required a certain component of rather large dimensions, and a drawing of this component was submitted. This drawing gave definite necessary dimensions, and rather severe changes of section were involved. Unfortunately, the producer did his very best to satisfy the engineer's requirements, and failed dismally. The reasons why he did so were at least two-fold: first, because the intial strains set up due to change of section could not be corrected by any form of annealing or normalising, and secondly, the metal required by the engineers could not by any means of heat-treatment satisfy their requirements as regards tests. The explanation was simple—the users knew what they required, but they knew nothing whatever about ferrous metallurgy, and were under the impression that all that was necessary was to produce a drawing, and the perfect component would follow. Some little time ago I had the pleasure of delivering a lecture on metallurgy of iron and steel to a branch of an engineering society in the north of England, and I was astonished to experience what little knowledge, amounting to almost nothing, was possessed by men who were engineers in every sense of the term, of the rudiments of the science of the metals they were using. I do not wish to suggest that all engineers are in this unfortunate state of ignorance—far from it—or the shipbuilders who quite recently were supplied with a nickel-steel rudder frame weighing 13 tons, requiring a very intricate heat-treatment, dared not have specified the dimension and the analysis of metal which they did.

In short, and again making reference to your correspondent, I feel convinced that the difficulties encountered and such as enumerated by him, are not due to any failure in the rules or laws of heat-treatment which have been laid down by research metallurgists and experienced steel-makers, but are due to an insufficient knowledge of the metal required on the part of the user. It is my firm belief that if engineers and other users of alloy steels were, during the course of their training, given a thorough grounding in the heating and cooling processes of steels—if they were informed how crystallisation and grain growth took place, if they knew the equilibrium and constitutional diagrams of the various more generally used alloy steels, and were also taught how to appreciate the different mechanical tests, tensile, Brinell, Izod, etc., then steel-makers, and heat-treatment engineers would not be asked to produce impossible treatments and test results upon components which, if properly designed would give no cause for worry, and would conform to all which was required of them.—Yours faithfully,

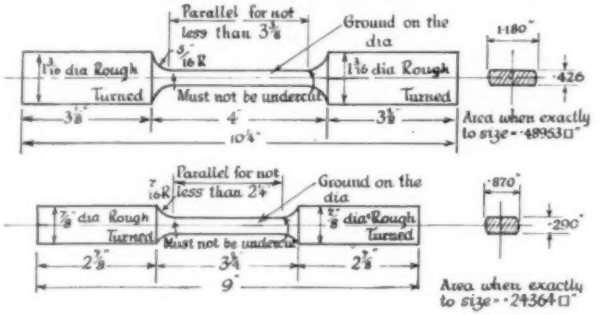
Walsall. C. Hubert Plant.

April 6, 1937.

Test-piece or Component

The Editor, Metallurgia.

Sir,—The letter of your correspondent, H. T., in your March issue will prompt readers to contribute to the discussion of a subject which must of necessity be controversial. To provide a basis for any arguments either in favour of component testing or in favour of representative test-pieces, experiences must be drawn upon, but it is well to remember that arguments can be advanced both for and against which are quite independent of either technical or commercial merit. These need not be stressed, but those aspects of the subject may be chosen as they appeal to engineers and metallurgists and to those who, like your correspondent, can claim at least some training and experience in both engineering and metallurgy.



Test-pieces to be finished to size before heat-treatment. Carburise and harden exactly the same as for crown wheels.

The Case for Component Testing

Many designers and metallurgists desire knowledge as to the actual strength and other properties of the whole component, and indeed, when investigations into the causes of failures have to be undertaken this knowledge would in not a few cases save a good deal of anxious thought. Many instances come to mind to illustrate the desirability of obtaining just this type of information, and many will feel that had adequate data of this nature been available during designing stages many failures would not have occurred and unnecessary waste of money could have been prevented. To quote just one example: it was found necessary to know the maximum loading which could with safety be borne by the teeth of a motor-car crown-wheel in its carburised and hardened condition. In particular it was desired to know what was the direct influence of the hardened case upon those properties upon which designers base their calculations in choosing tooth form and pitch. A test-piece was, therefore, devised to represent a tooth of the component, the form of the test-piece being given in the accompanying diagram. Without discussing the merits or demerits of this particular tensile specimen, it is sufficient only to add that what information was thereby obtained was of a highly controversial nature and left the conviction that a more useful purpose would have been served had destructive tests upon the complete component been undertaken instead. The difficulty that must arise in attempting any such thing is clearly that of ensuring that the conditions of the test must be as nearly as possible representative of service conditions. There is no doubt, therefore that, providing this can be achieved. tests upon the component are superior to those undertaken with either machined or unmachined test-pieces.

The testing of cast iron is, of course, a subject which has

been well to the fore in recent years, and few will deny that it is impossible to secure in the test-piece material which is representative or even approximately representative of the casting as a whole. Indeed, in many instances where test-pieces have become a matter of routine practice, even those who use them do not pretend that they fulfil every purpose. These known facts can, of course, be used as arguments in favour of component testing, and from another viewpoint can be employed to provide adequate reasons against its more general adoption, but much will depend upon the nature of the test to be undertaken and upon the type of information sought. Indeed, instances could be quoted of extreme cases in which on the one hand testing by test-pieces to give as is thought precise control of processes, has become an obsession, and instances on the other hand where little or no testing is undertaken.

There is no doubt, however, that publication of the results so obtained from tests upon components would be of considerable interest, more especially if details of the machines devised for use are presented for discussion. While the machines thus used would frequently be of a somewhat elaborate and costly nature the results obtained would further convey considerable commercial advantages in certain important directions, as, for instance, in the development of both standard and special testing equipments. There are, however, certain important factors operating against this course.

The Case Against Component Testing

That the testing of components is not universally adopted is beyond argument, and it is accordingly of interest to examine carefully the reasons operating against this practice being more generally adopted.

Not the least of the arguments which can be advanced against this method of testing is that of convenience. It is often incumbent upon responsible officials to make quick decisions, even though these decisions are known to provide but temporary expedients. While it would, of course, under these circumstances be of very great advantage to have at hand such data as may be obtained from tests upon components, it is seldom convenient to await their acquisition. Indeed it becomes almost impossible to achieve this since the type of information required in any such emergency cannot readily be foreseen. Hence it is frequently necessary to devise some rapid test in order to arrive at a conveniently quick decision. If component testing is to be undertaken machines and special fixtures must of necessity be designed and manufactured, and these will assuredly be the more complicated the more closely approaching to service conditions the test is desired to be. Hence a test-piece of some sort and a machine of some standardised form can clearly provide rapid means of obtaining, if not all the information desired, at least sufficient for immediate needs. Also, in many instances, and indeed in the majority of cases, figures representing properties are not needed and would, moreover, confuse the issues if they were secured. A decision can frequently be made by examination of a property, such as a fracture, to which no numerical value can be given. It must also be remembered that very little of the information and data derived from engineering measurements are of an absolute nature, but they are, in fact, relative to something else as standard. Hence test-pieces can in most instances be employed with advantage, since the relationship to absolute values of the data so obtained will be known approximately. Furthermore, excessive cost in relation to the practical value of the results secured by component testing is no doubt one of the major causes operating against this practice and its more general employment in engineering methods.

It must also be realised that in not a few instances it is not the properties of the component as a whole which are desired, but only those of a portion of a component. This will be evident from the example quoted above, and in that case the information sought could quite easily be obtained, and at lower cost, by the use of tensile test-pieces of standard form.

From another commercial standpoint it may be argued that a company which has spent a considerable sum of money to secure the special data obtained from tests upon components will hardly be disposed to publish its results for the free use of its competitors. Some, nevertheless, have within recent years shown evidence of a move in this direction, and when large components have been involved small scale models have been used instead. It is, of course, just this type of opposition which has had to be broken down in other directions.

Summary

To summarise the position as it now exists, it is clear that many valid arguments, both technical and commercial, may be found in support of component testing, and just as many reasons may be advanced in favour of the preferential use of test-pieces. It is, therefore, necessary to decide each problem upon its merits, as governed by individual needs and circumstances, for no hard and fast rules can be made.

Yours faithfully,

April 10, 1937. W. F. Chubb.

Electric Furnaces for Aluminium

The Editor, Metallurgia.

Sir,—I have read with interest the article on aluminium melting in an induction-type furnace, by Mr. A. J. Gibbs Smith, which appeared in your January issue, but I consider it desirable to record certain observations without which the information given is likely to prove misleading, particularly if applied to users in this country.

Firstly, the rate of exchange taken for converting values to sterling is approximately 20 RM to the £, whereas, to-day the value of, say, 12.20 RM is nearer the mark.

Another point which is, however, of less importance, is that whereas 7% for interest may be an accurate figure in Germany, 4% should be adequate in this country, where money is cheaper.

With regard to the question of metal loss, which is of course, linked up with that of the quality of the metal, the oil furnace described can scarcely be taken as representative of modern plant heated by this fuel since the illustration of a section of aluminium cast from this furnace does not compare at all with the high-quality metal regularly being obtained from oil-fired crucible furnaces, nor does the figure of 1·8% metal loss compare with oil-fired crucible melting furnace practice to-day—a loss exceeding 0·8% would, for instance, be looked upon as excessive in a modern furnace of this type.

OIL CRUCIBLE FURNACE.		ELECTRIC FURNACE.	
Metal loss, 0·8% at £100 per ton	16/-	Metal loss, 0·8%	16/-
Oil, 1½ gals. per cwt. = 12%, at 75/- per ton	9/-	Current, 360 units at ½d. per unit	15/-
Crucibles	5/-	Lining, 3,000 heats at 1,000 RM at 12·20 = £82	1/-
Linings	7d.	Interest, 4% on 25,000 RM at 12·20 = £2,050	1/4
Interest, 4% on 4,000 RM at 12·20 = £328	1,250 tons 2½d. p/a.	Depreciation, 15% on £2,050	1,250 tons 9d. p/a. 5/-
Depreciation, 15% on £328	9d.		
Total	31/7	Total	38/4

With regard to fuel costs, the price of oil would be nearer 75s. per ton in this country than the figure given, which is £5 9s. 4d., and the price of ½d. per unit for electricity can be taken as a fair average.

The effect which the above considerations have on the relative melting costs given is striking—the costs of the electric unit being actually higher than the oil furnace. In order to illustrate this, I include approximate melting costs of an oil-fired crucible furnace of half a ton aluminium capacity, and also repeat the costs given for the electric furnace with appropriate corrections made for the price of current, metal, and rate of interest.

With regard to the current consumption given—360 units per ton, it is worthy of mention that in a recent publication issued by one of the leading electric-furnace manufacturers in Germany, marketing induction furnaces amongst other types, it was admitted that a current consumption of 400 units per ton of aluminium in an

induction furnace was a favourable figure, and that the possibility of a lower consumption was very remote.—Yours faithfully,

London, N.W. 8. J. F. G. DOWNES.
March 10, 1937.

Sir,—Your recent letter, containing a copy of a communication received in connection with data given in my article, has been following me from place to place on the Continent, and even now I can, unfortunately, only answer it from memory of its contents.

With regard to the point raised, that for a fair comparison the figures should be converted at 12·50 to the £, if it is a question of an English user buying a furnace in Germany, this is undoubtedly what would have to be done. If, however, it is merely a question of considering running costs, etc., from the internal German point of view, I do not agree. The internal prices in Germany, when the figures were compiled, had certainly not increased the proportion of 12½ to 20½. The whole subject is too complex to argue in the space of a short letter, but it was more convenient to make the conversion at par.

I think the figure given for melting loss is a fair one, and quite typical ; but I am writing without data. Mr. Downe's letter is most interesting, as it raises so clearly several other points of view, and I hope to be able to return to the matter at a later date.—Yours faithfully,

Sheffield, A. J. GIBBS SMITH.
April 5, 1937.

Aluminium Alloy R.R. 56

MODERN progress has created a demand for materials having a high strength/weight ratio, and as the heat-treatable alloys fulfil this condition they have naturally been adopted both for transport purposes and for various types of machinery, especially for parts which are subjected to high reciprocating speeds and centrifugal loading. Of these mention may be made of the R.R. series of alloys used in the forming of castings, forgings, and sections and sheets. One of this series of alloys is that known as R.R. 56, and it has been developed as a wrought material in the form of tubes, sections, and sheets. A typical composition of this alloy is as follows :—

Cu.	Ni.	Mg.	Fe.	Ti.	Si.	Al.
2·0 ..	1·3 ..	0·8 ..	1·4 ..	0·1 ..	0·7 ..	Remainder %

Tubes made from this alloy are covered by Air Ministry Specification D.T.D. 220, and extruded sections by B.S. Specifications L. 40. Particulars of the mechanical properties required by these specifications are given in Table I.

TABLE I.

MECHANICAL PROPERTIES REQUIRED BY AIR MINISTRY AND B.S. SPECIFICATIONS COVERING R.R.56 TUBES AND EXTRUDED SECTIONS.

—	D.T.D. 220 Tubes.	L.40 Bars, Extruded Sections and Forgings Fully Heat-treated.
Proof stress—(0·1%), tons per sq. in.	22 min.	21 min.
Maximum stress, tons per sq. in.	27 min.	27 min.
Elongation, %	—	10 min.
180° bend test (on strip cut transversely)	rad = 5T.	—

Sheets and strips in R.R. 56 are covered by the Air Ministry Specification D.T.D. 206, the material being supplied in one of the three following conditions : (*a*) Softened ; (*b*) quenched only ; and (*c*) quenched and aged, according to the amount of bending and forming which is subsequently to be performed. In the case of (*a*) the full heat-treatment, and (*b*) the ageing treatment, are carried out after suitable forming operations. Table II. shows the mechanical properties required by the specification.

Typical mechanical properties of R.R. 56 are given in Table III. The heat-treatment necessary to secure optimum mechanical properties consists of two operations, the first being known as the " solution " or " quenching " treatment, in which the material is heated to 525°–535° C. for 2 to 4 hours, and quenched in warm water at 70° C., cold water or oil. This operation leaves the material in a medium strength condition and with relatively good ductility ; for example, the maximum stress will be about 22–26 tons per sq. in., and the elongation per cent. approximately 15–20. The second operation consists of the " precipitation " or " ageing treatment "—*i.e.*, heating to 165°–175° C. for 15–20 hours (or alternatively, 200° C. for 2 hours), followed by cooling in air or water.

The fact that it is the second operation which produces the final high strength condition has several important advantages. Since the material after the first quenching is not in a particularly hard condition, it can easily be cold-formed and can then be hardened by the relatively simple second operation which, because of the low temperature at which it occurs, avoids any risk of distortion. Moreover, " R.R. 56 " does not " age harden " to any extent at ordinary room temperature after the quenching

TABLE II.

MECHANICAL PROPERTIES REQUIRED BY AIR MINISTRY SPECIFICATION D.T.D. 206 COVERING R.R.56 SHEETS AND STRIPS.

—		Condition of Test Piece.		
		Softened.	Quenched only.	Quenched and Aged.
Proof stress (0·1%), tons per sq. in.		—	—	21 min.
Maximum stress, tons per sq. in.		—	—	27 min.
Elongation % (on gauges thicker than 12)		10 min.	12 min.	10 min.
180° bend test (on 12 gauge and thinner)		rad = 1T	rad = 1½T	rad = 3T
90° reverse bend test gauge (on 12 gauge and thinner)				
Gauge.	Radius of Bend.			
30 and thinner	0·050 in.	7 bends, min.	11 bends, min.	11 bends, min.
26 to 29	0·070 in.	4 " "	8 " "	8 " "
22 to 25	0·100 in.	2 " "	5 " "	5 " "
20 and 21	0·144 in.	1 " "	4 " "	4 " "
18 and 19	0·192 in.	1 " "	3 " "	3 " "
16 and 17	0·252 in.	1 " "	3 " "	3 " "
14 and 15	0·320 in.	1 " "	3 " "	3 " "
12 and 13	0·400 in.	1 " "	2 " "	2 " "

TABLE III.

TYPICAL MECHANICAL PROPERTIES OF R.R. 56.

Heat treatment.	Tensile Proof Stress, 0·1% Tons per Sq. In.	Tensile Maximum Stress, Tons per Sq. In.	Elongation, %	B.H. No.	Fatigue Limit, Tons per Sq. In.
(*a*) Annealed	6–8	12–16	20–25	55–65	—
(*b*) " Solution " only	10–13	22–26	15–20	80–100	± 9·3*
(*c*) Complete (*i.e.*, "Solution" and "Ageing"	21–23	27–32	10–15	125–148	± 10·7*

* For 40,000,000 reversals of bending stress.

treatment, so that forming operations need not be carried out immediately after the quenching. Hence those manufacturers who do not wish to instal the necessary quenching furnace equipment can obtain their material in the quenched form, carry out the necessary manipulation, and then " age harden " it. The elevated " ageing " temperature is also an advantage, because it is of the same order as that used for enamelling, and, therefore, this operation can be undertaken without any danger of modifying the properties of the alloy.

In order to reduce the alloy to its softest condition, it should be annealed at 330°–350° C. for from 1 to 4 hours.

This alloy is used for forgings and stampings for highly stressed parts, such as aero engine crankcases, connecting rods, airscrew blades, etc. ; in addition, it has many uses in the form of extruded sections, tubes, and rolled sheet. Interesting information regarding its applications in the latter form are given in a booklet recently issued by High Duty Alloys, Ltd., Slough, Bucks, copies of which are available on application.

Some Notes on Drop Forging

The importance of quality is increasing the demand for metal components which can be mechanically worked, because mechanical work multiplies the strength of the material; for this reason the demand for drop forgings is increasing.

DURING recent years the hot- and cold-shaping of ferrous and non-ferrous metals by drop-forging in dies, by means of hammers, forging machines, and presses, has assumed great importance. The birth of this craft is wrapped in the mists of antiquity as far as Britain is concerned, but it is on record that in New England, U.S.A., the Yankee toolmakers adopted this method about 50 years ago, where a limited amount of work was done in dies, to impart a finish to the material which had previously been hand forged, also to impart a degree of uniformity which was unattainable on the anvil with the common tools of the smith.

Drop-forging is a trade in itself, and the process in its varying degrees of accuracy and finish is one for special study before the results can meet specification requirements. The control of temperature in heating for forging is an important factor in achieving success, as the forgeable metals and alloys must be worked between certain temperature limits to produce the most desirable properties in the material. The procedure commences with the making of suitable die blocks from which impressions are cut to conform with the requirements of the forging. The die-sinking is usually effected by machinery to as near the required size as possible, so that the minimum is left for finish by hand. Lead or wax proofs are invariably taken from the dies, which should be an exact replica of the shape and size of the required forging. These proofs are frequently accepted as a sample for approval, though modifications to the dies are often necessary before a sample is finally approved. Even when the dies are approved in this way, the first few forgings produced are invariably submitted to inspection and tests to ensure that they are within stipulated limits. Economy in production, from the commercial point of view, depends upon the minimum of hand work to obtain the desired shape, the allowance of suitable guttering for flash, adequate draw or draft, and the size of the die-blocks in relation to the die impression and the material to be forged.

Each metal and alloy used in making drop forgings presents its own peculiar problems, and, in some instances, such as the aluminium alloys in non-ferrous metal forging, and stainless steel on the ferrous side, may be regarded as the work of specialists. The handling of stainless steel, for instance, is one of the most intriguing branches of the drop-forging trade, as it demands manipulation within the narrowest limits of temperature to obtain the most satisfactory results.

Drop-forging is now the recognised process for the production of a large number of components which are required to possess high mechanical properties, such as aircraft parts like connecting rods, crankshafts, etc., and all industries where the superior properties of a forging have a special value, typical examples of which are shown in Fig. 2. In view of the key operations these forgings invariably perform, it is not surprising that considerable study is applied to the perfection of each component produced as a drop forging, to obtain the proper grain flow and highest mechanical properties by subsequent heat-treatment.

One of the most important characteristics is the grain flow; the direction of this is of vital importance in the majority of forgings, as, for instance, in gear blank forgings, where the gears are to resist shock loads. For these forgings flow lines must extend outwards from their centres to the extreme end of each individual tooth. In this instance, by forging a gear from a flat bar, proper grain flow will not be obtained except in some parts of the gear, and some of the teeth would have the grain flow in an incorrect direction, and the teeth would consequently be of varying strengths, especially in their resistance to shock. A more satisfactory method is by hammer upsetting, by which correct flow can be obtained with maximum and uniform strength in all the teeth of the gear.

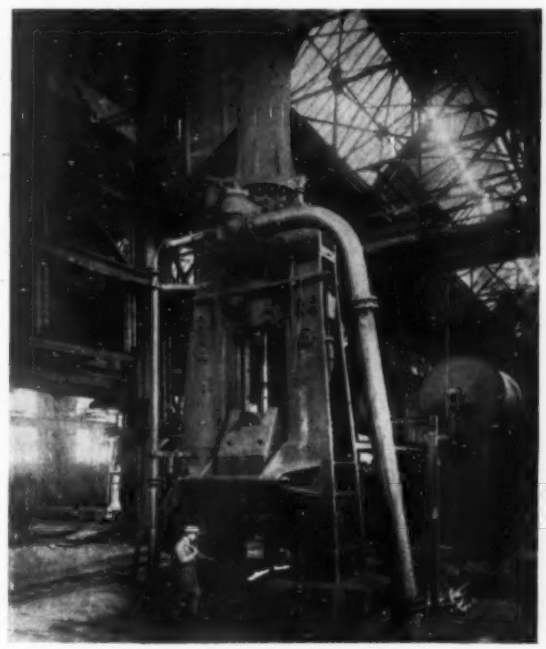


Fig. 1.—Large drop-forging hammer.

As a rule, there is considerable variation in the sectional shape and thickness of a forging, and to facilitate production it is customary to proceed by stages. This method not only assists in giving the correct flow of the metal, but reduces the likelihood of lapping and enables the minimum amount of material to be used with a high degree of accuracy. It necessitates preliminary preparation during which the metal is roughly formed to the shape of the required forging, in many instances it is more economical to sink dies for these rough shapes rather than to prepare them by hand under a power hammer. The stages, which vary according to the amount of work in the finished forging, include cutting up the material in suitable sizes prior to forming; necking, drawing, and probably bending; and preparatory dies may subsequently be used to give the metal a shape near to the final shape of the forging.

The setting of the dies is a very important part of the procedure, not only with regard to accuracy, but in maintaining steady output. The die blocks should be warmed well in advance of their use, to make sure that they are in a suitable condition for setting when die-changing is necessary. Two methods are employed for fastening the dies, one in which the top die is keyed to the top and the bottom die adjusted in position by puppet screws; the second method

is that in which both top and bottom dies are securely keyed.

There are wide variations in the types of hammers used; the choice depends largely upon the power supply. Steam or pneumatic hammers are frequently employed, especially when steam or compressed air plant is installed for other purposes, but since electric current is now generally available at a reasonable cost, hammers of the friction lifter type, driven by electricity, have many advantages. Many believe that hammers in which the top weight is 3 tons or more should be driven by steam or compressed air, but many electrically operated hammers are in use; on the other hand, drop stamps in which the top weighs a few hundredweights, are commonly used under steam power. In each case, it may be assumed that the hammers are economical in use. A large drop-forging hammer is shown in Fig. 1.

Power presses are necessary to remove "flashes," which represent excessive metal pressed between the parts of the die. The presses may be of the geared type, or power may be obtained from a heavy fly-wheel through a striking gear. The former is generally used for the heavier work, though the direct-motion type is quicker in action. Many of the modern types are fitted with multiplate friction clutch and brake mechanism, by means of which complete control can be obtained at any point in the stroke.

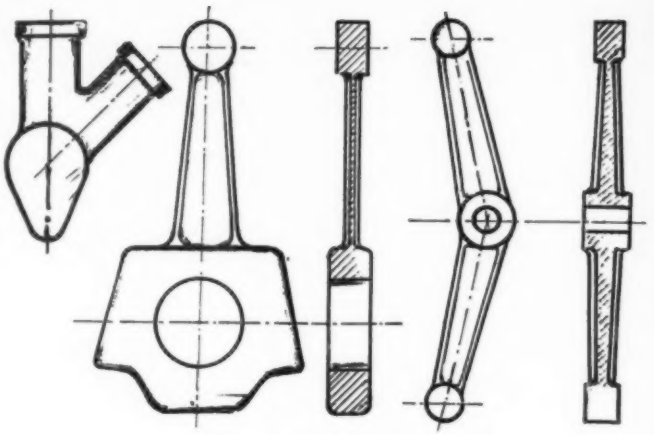


Fig. 2.—Some typical forgings.

The Magnitogorsk Iron and Steel Plant

THE iron and steel plant at Magnitogorsk, in the Urals, which produced its first pig iron about five years ago (on February 1, 1932), is at present not only turning out pig iron at a lower cost than any other works in the Soviet Union, but, at the end of 1936, registered a profit of 33 million roubles. The plant to-day includes four blast-furnaces, each of a volume of 1,180 cubic metres, 12 open-hearth furnaces, each with a capacity of 150 tons; a blooming mill; four coke batteries, each of 69 ovens; a number of rolling mills; an ore mine; an electric power station; and various subsidiary shops and departments.

During the five years of operation, the plant has turned out nearly five million tons of pig iron, 2·6 million tons of steel, and two million tons of rolled metal. In the same period the Magnitogorsk Mine has produced over 18 million tons of ore. The plant's output of pig iron has increased from 327,000 tons in 1932 to 1,557,000 tons in 1936. Its output of steel has grown from 85,000 tons in 1933 to 1,168,000 tons in 1936, and rolled metal from 58,000 tons to 960,000 tons during the same period. Last year this plant produced 10·8% of the total Soviet output of pig iron, 7·2% of the steel, and 7·7% of the total output of rolled metal.

The latest of the blast-furnaces, open-hearth furnaces, and rolling mills at the Magnitogorsk plant are claimed to be among the most up-to-date in the world. Practically every process is mechanised, including the loading, unloading, and sorting operations in the stock departments.

Despite the predictions of some foreign experts that the Magnitogorsk plant would not be able to work to estimated capacity, most of the units have far exceeded these capacities. Blast-furnace No. 3, whose estimated daily capacity was 1,000 tons of pig iron, attained that figure on the fifteenth day after its opening, and blast-furnace No. 4 on the twenty-second day of operation. The advent of the Stakhanov movement at the end of 1935 caused a big upward jump in production. To-day the four blast-furnaces are daily turning out 5,000 tons of pig iron, while blast-furnace No. 1 often produces 1,600 to 1,700 tons a day. Big increases in output are also recorded in the open-hearth furnaces. The old estimated output of 90,000 tons of steel a year has been increased to 165,000 tons. The output of steel per square metre of heating surface has jumped from 3·46 tons in 1933 to 4·84 tons in 1936, some furnaces even doing better than that. Furnaces Nos. 4 and 5 turned out 5·18 to 5·19 tons per sq. metre of heating surface in 1936.

Contrary to the prediction that the Magnitogorsk blooming mill would not be able to handle more than one million tons of rolled metal a year, and that only within five or six years, the first blooming mill, which started operating in 1933, produced 1·2 million tons of rolled metal in 1936, and the estimate for this year is 1·6 million tons.

When construction of all its units is completed, the Magnitogorsk plant will consist of eight fully mechanised blast-furnaces with an aggregate annual output capacity of 4·3 million tons of pig iron; three departments, containing 29 open-hearth furnaces, each of 150 tons capacity-capable of producing an aggregate of 4·77 million tons of steel a year; three blooming mills; six rolling mills and other units. The rolling mill department is expected to turn out 1·2 million tons of rails a year, and 2·5 million tons of various types of rolled metal.

The mine belonging to the plant is expected to produce 12 million tons of ore a year. To prepare this ore for smelting, a number of washing, concentration, and other plants have been built. The coke plant of Magnitogorsk, when completed, will consist of 10 batteries, each comprising from 65 to 69 ovens, and capable of turning out 4,235,000 tons of coke a year, together with large quantities of various chemical products.

With the completion of all its departments, the Magnitogorsk plant will produce more pig iron, steel, and rolled metal than all the metallurgical plants of pre-war Russia in 1913. It will be the largest plant of its kind in Europe.

"The Flow of Metals"

THE twenty-seventh annual May lecture of the Institute of Metals will be delivered by Professor E. N. da C. Andrade, D.Sc., Ph.D., F.R.S., on Wednesday, May 5, at 8 p.m., entitled "The Flow of Metals." The lecture will be given in the Hall of the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W. 1. Tickets of admission can be obtained from Mr. G. Shaw Scott, 36, Victoria Street, London, S.W. 1.

Metallurgical Progress and the Electrical Industry

By L. SANDERSON

Some recent developments of special interest to the electrical industry are briefly reviewed in this article, particular attention is directed to a number of die steels for plastic materials.

METALLURGICAL progress is so rapid that it is difficult to compress the numerous developments of the last year into a brief article, but a brief review of the advances that have a special application to the electrical industry, will be of interest.

Cutting Tools

Continuous research and experiment have proceeded with cutting tools and a large British firm is shortly marketing a new patented type of tungsten-carbide tipped tools for cutting cast-iron and non-ferrous metals. The alloy with which the tools are tipped has been shown by actual use to be rather tougher than the former types of tungsten carbide, thereby reducing the possible breakages. Twist drills for drilling various materials—*e.g.*, aluminium, bakelite, etc., are being made with polished flutes, the advantage of this being that the drillings produced are more readily removed and do not tend to collect in the hole thereby clogging the drill and possibly causing fracture.

Brazing Furnaces

Electric furnace brazing of steel parts in furnaces of the continuous type with scientifically controlled atmospheres has been adopted in many plants, especially for the manufacture of electric refrigerators. By this process, joints of greater strength and better finish are produced, while the costs are lower. America has produced an improved process for electro-plating non-corrosive chromium on other metals. This new method consists of employing complex organic chemicals to obtain the desired " spreading " effect for electricity. With the chemicals in the electroplating bath, the electric current no longer coats only the high spots, but also plates the hollows.

Columbium Welding Rods

In welding, one of the most important developments has been the introduction of welding rods containing the rare element columbium. The purpose of these is the welding of those qualities of stainless austenitic steels of the nickel-chromium type to which titanium or columbium has been added in order to stabilise their corrosion-resisting characteristics. The welding with these rods does not set up any great radiation or loss of columbium, and the welds produced by their means are sound and proof against corrosion. The extent of the columbium in the rod is roughly six to ten times as much as the carbon percentage. No alteration in welding methods is necessitated by the presence of columbium in the welding rod. The makers advise a neutral flame with adequate flux, while backhand welding may be used, thereby minimising the risk of warping.

In connection with the welding of steels of the low alloy type, it is worthy of mention that a new type of high-nickel chromium-steel welding rod has been invented for the purpose of producing a tough austenitic weld seam, which will not deteriorate over a period of time, and at the same time does not call for a stabilising or normalising heat-treatment after welding to restore the structure and characteristics of corrosion-resistance.

Nickel-Aluminium Magnet

The sensational progress of the nickel-aluminium permanent magnet steels has made it necessary for steel manufacturers to possess some type of testing mechanism suitable for employment in the production control of alloys possessing a coercive force greater than that of the steels previously used. To this end, a German manufacturer has invented a new double-yoke type of apparatus, specially designed for testing those magnets made from the nickel-iron-aluminium and nickel-iron-aluminium-cobalt types of alloys, and for ascertaining their remarkable magnetic properties. The apparatus is quick, efficient and capable of adaptation to a wide range of shapes and sizes.

The discovery of the nickel-iron-aluminium-cobalt permanent magnet alloy has been so widely announced that there is no need to dwell upon it here. It is interesting to note, however, that research into new magnet steels continues, and within recent months patents have been taken out in various countries for magnet alloys of nickel aluminium iron copper type, for nickel-cobalt titanium metal, and even for a magnet steel containing high percentages of silicon. The sintering of certain ferromagnetic oxides such as cobalt ferrite and iron oxide to form magnets has also been attempted, while a range of platinum iron alloys have also their advocates, the platinum percentage being about 78.

Alloy for Acceleration Control Grids

A 55/45 nickel-copper alloy has been found highly satisfactory for acceleration-control grids of electric locomotives, being much superior to cast iron for this purpose. The new material has a reasonably high specific resistance, and at the same time possesses a virtually constant vibration resistance over a wide range of operating temperatures. The new alloy is supplied in the form of castings.

New Die Steels

The electrical industry continues to utilise large quantities of plastic materials in moulded form. This has led to an increased demand for satisfactory die steels, capable of standing up to long runs on bakelite, etc. Four main types of steel have been evolved for this purpose. The first is a high-carbon, high-chromium material, which has considerable resistance to corrosion and erosion, and is capable of taking a mirror polish. It is hard enough to serve as a master hob in the hobbing process, but is still tough enough to resist the stresses developed without breaking down. This steel can be utilised for master hobs or direct-cut moulds.

The second steel is a high-chromium quality of stainless character, and is especially suitable for direct-cut moulds, and for withstanding the corrosive attack of some of the powders of the urea type. It can be readily machined, and will take a high polish. The third material is also a high-chromium one, but has a slightly lower carbon content than the previous type. It is usually supplied specially annealed, so that it can be fairly easily hobbed, possessing in this state a Brinell hardness number of only 156. The fourth material is also an alloy steel suitable for either hobbing or direct-cut moulds. It is supplied in the ready heat-treated state for direct-cut moulds, and therefore, no hardening is necessary. After annealing, it has a Brinell hardness number of 156 at most. For hobbing it should be hardened.

Carbon-chromium die steels have been used with great success in the stamping out of lamination blanks for electrical machinery. One such blank measuring 14½ in. diameter × 26 in. gauge, was composed of a material highly abrasive in nature and of high silicon content. The

carbon-chromium steel die blanked from 300,000–500,000 of these laminations without a grind.

Heat-resisting Steels

Heat-resisting steels have likewise developed considerably, and as compared with the one quality first put on the market and capable only of being supplied in casting form, there are now no fewer than six different types. The first of these is an austenitic nickel-chromium steel, possessing great corrosion-resisting properties, and the ability to withstand intergranular attack. It is also resistant to scaling under heat, and at temperatures up to 800° C. it possesses relatively high mechanical strength.

The second material is an austenitic nickel-chromium-tungsten steel, non-scaling and possessing good mechanical strength at temperatures up to 900° C. It is specially suitable for parts subjected to heat up to 950° C. where a measure of mechanical strength is needed. It can be obtained in either bar or forging form. The third steel is an austenitic high chromium-nickel steel, which will not scale at temperatures up to 1,050° C. It has fair mechanical properties at these high heats, and is an excellent general steel for heat-resisting purposes.

A fourth steel is a plain high chromium material with extreme resistance to corrosion and scaling under heat. Its specific utility is for those instances in which the temperature is fairly constant. Wherever repeated heating and cooling are met with, resulting in heavy internal stresses with the danger of cracking, it is less suitable than other heat-resisting steels. Its resistance to scaling at heats up to 1,250° C. is very great.

The next material is also a high nickel-chromium steel, possessing the highest mechanical strength at high temperatures of any of the steels enumerated, together with excellent resistance to scaling. It is quite suitable for employment in fluctuating temperatures up to 1,150° C. The last steel of all resists scaling considerably and is not subject to intergranular attack at high temperatures. It can be employed for parts subject to severe fluctuations of temperature up to 1,150° C., and is a high nickel-chromium alloy.

In addition to the range of standard heat-resisting steels developed and outlined above, a new heat-resistant alloy has been introduced. This is an iron chromium-aluminium alloy, containing 37½% of chromium and 7½% of aluminium. It is specially designed for wire for electric-furnace resistor elements, and is said to have many times the serviceable life of the standard nickel-chromium alloy. The temperature range for operating the metallic resistor type of electric furnace has thereby been raised to 1,250/1,320° C.

Stainless Steels

The stainless steels do not show any marked advance on the analyses and characteristics of last year, but it has been found that nitrogen has a beneficial effect when used as an alloy in chromium steels. One of its effects is to bring about a considerable refinement of the grain, while also greatly increasing the hardening capacity of low carbon 12/14% chromium steels. Strength and toughness are improved without in any way increasing the hardness associated with brittleness.

Effect of Uranium

Some interesting work has been done on the effect of uranium on steel. While it is not, at the moment, likely that this element will be used on a commercial scale as an alloy of steel, experiments showed that its addition increased the degree of hardening for a given hardening temperature, and also slightly reduced the susceptibility of the steel to overheating. The introduction of uranium leads to the formation of carbides, as is the case with chromium. It does not seem, however, that uranium leads to any improvement in the mechanical characteristics of constructional steels, or at most only to a slight improvement.

It will be seen that the metallurgist has by no means stood still during the past year, and there is reason to believe that the next 12 months will see other interesting developments.

Growth of the Platinum Industry

FOUR hundred thousand ounces of the platinum metals were puchased in 1936, an increase of 45% over the 1935 figure. A part of these purchases may have been due to speculation or investment, but the volume of actual consumption in the arts and industry and the many uses to which these metals have been put is a further evidence of the effectiveness of progressive research.

The jewellery industry continues to be a foremost user of these metals. Industrial recovery was reflected in the amount of platinum purchased for jewellery, and in this connection the increase in the marriage rate contributed largely to the demand.

Investigations into the properties of the range of metals used by dentists further strengthened the position of platinum and palladium in this field. The precious metal alloys of platinum-gold-palladium are still the best for dental work because they are strong, readily cast and shaped to complex forms, and are not affected by the acids of the mouth.

Platinum-clad material has reached the practical stage of production. A thin layer of platinum may now be inseparably bonded to some other metals, and large laboratory or industrial vessels may now be economically manufacturered which are as strong as required, and at the same time impervious to corrosive attack.

The output of sulphuric and nitric acid also increased during the past year, and since platinum or platinum-rhodium is frequently used as a catalyst in the manufacture of these acids the sale of these metals has reflected this activity.

The jewellery industry is also absorbing larger quantities of paladium and palladium leaf is being more commonly employed for the lettering and ornamentation of fine book-binding.

The rhodium plating of silver ware has offered a means of avoiding the tarnishing to which silver is so subject, a very thin layer of rhodium, which is not expensive to apply, being sufficient to prevent the discolouration of the silver.

The increased sale of platinum has also been responsible for the sale of more iridium, since this metal is used by jewellers to harden platinum.

The Chemist in Industry

THERE was more than ordinary interest for the thousands of chemists in industrial appointments in this country in a recent symposium given at Manchester under the auspices of the Society of Chemical Industry. The discussion, especially on the subject of "The Chemist in Industry: His Induction, Functions, Influence, and Rewards," received much attention from industrialists. There are few more fruitful sources of discussion amongst scientific workers than the subject of the advantages and disadvantages of industrial occupations. In this instance the Society of Chemical Industry brought together several notable leaders of the chemical industry, and their views were fully representative of opinions held within the industry.

The meeting was held in two sessions. At the first, the first part of the subject—"The Induction and Function of the Chemist in Industry"—was discussed. The Government Chemist, Dr. J. J. Fox, and Prof. J. C. Philip, F.R.S., of the Imperial College of Science and Technology, as well as Mr. F. Schofield, M.Sc., of the Manchester College of Technology, and Mr. C. M. Whittaker, of Courtaulds, Ltd., contributed papers. The concluding half of the symposium, on "The Chemist's Influence and Rewards," centred on papers contributed by Dr. A. E. Dunstan, of the Anglo-Iranian Oil Co., Ltd.; Mr. H. Ballantyne, F.I.C., of Lever Bros., Ltd.; Mr. G. E. Collins, M.Sc.Tech., of the Shirley Institute; and Mr. J. Rogers, O.B.E., of Imperial Chemical Industries, Ltd.

International Association for Testing Materials

The London Congress

THE Congress of the International Association for Testing Materials, to be held in London, on April 19–24, 1937, will probably be the most comprehensive of its kind to be held. Representative of the national testing associations or equivalent organisations in about twenty-five of the leading industrial countries of the world, this Association is controlled by a permanent Committee composed of representatives of these countries. Its function is to secure international co-operation and an exchange of views, experience and knowledge in regard to materials and their testing. The subjects for discussion at the Congress have been divided into four groups, for each of which a Group President is responsible. There are groups embracing metals, inorganic materials, organic materials, and subjects of general importance, each of which being divided into sub-groups for convenience in classification. About 210 papers will be presented.

METALS

The group under this heading is presided over by Professor C. Benedicks, Sweden, Dr. H. J. Gough, F.R.S., of Great Britain, being vice-president. About 77 papers are presented in this group, being divided into sub-groups under (1) Behaviour of Metals (mechanical and chemical) as dependent upon temperature, particularly in regard to high temperature; (2) Progress of Metallography; (3) Light Metals and Their Alloys; and (4) Workability and Wear.

Behaviour of Metals as Dependent upon Temperature

This sub-group is divided into two sections, one which concerns itself with mechanical properties, and the other with chemical properties. Some seven papers are concerned with creep in general and creep-testing methods. The phenomenon of creep recovery is discussed by Mr. H. J. Tapsell, in which data are given from test specimens which had been creeping under stress at a high temperature and which were unloaded at that temperature, to show contraction with time or creep recovery. Drs. C. L. Clark and A. E. White discuss certain theories developed on the mechanism of creep, based on researches conducted in the laboratories of the University of Michigan. Though these theories should not be regarded as completely established facts, they present a plausible explanation of this phenomenon and explain the influence of many factors which affect the creep resistance. Dr. A. Nadai discusses formulæ for calculating the creep of metals, while several creep-testing methods are discussed in papers by Par L. Gottignies, Von Ing. Robert Ludwig and Ing. H. Wüstl, Von Prof. Dr.-Ing. Anton Pomp, and Dr. R. W. Bailey. Testing results are discussed in papers by Prof. Dr.-Ing. V. Jarеs and Dr.-Ing. L. Jeníček; Dr. W. H. Hatfield; A. Von Zeerleder and R. Irmann; J. J. Kanter; C. E. MacQuigg; Von Prof. Dr. G. Welter; and Par Prof. Ing. Vicente I. Garcia.

The influence of temperature on the chemical properties of metals is discussed under two main headings: oxidation and corrosion in general, and testing methods and results, under each of which five papers are presented. The reaction of heat-resisting steel in hot gases is discussed by Von Prof. Dr.-Ing. E. Houdremont and Dr.-Phil. G. Bandel; Dr. U. R. Evans considers corrosion as influenced by increased temperature; chemical properties and stability at high temperatures by Dr. C. H. M. Jenkins; the oxidation of molten metals by Prof. Dr.-Ing. A. Kurpkowski; and factors influencing corrosion at increased temperature by Professor Carl Benedicks. The papers concerned with testing methods and results include recent progress and applications of research on corrosion gases by Prof. A. Portevin and H. Jolivet; corrosiono xidation and sulphur resistance of non-ferrous metals in high temperatures by Dr. W. Rohu; influence of temperature no the formation of pitting in stainless steel, by Dr. Sven Brennert; testing high endurance oxidation-resistant alloys by F. E. Bash; and life-testing Smith alloy No. 10 by Prof. S. L. Hoyt and M. A. Scheil.

Progress of Metallography

This sub-group is considered under several headings, including micro- and macrography; X-ray interference; electron interference and emissivity; equilibrium diagrams; non-metallic inclusions; solidification of ingots; and recrystallisation. In all, some twenty-five papers are presented in this sub-group by Dr.-Ing. M. Niessner; Prof. A. R. Matthis; W. H. Dearden, M.Sc.; Prof. Dr. Köster; Dr. Francis F. Lucas; Dr. M. C. Neuburger; Prof. U. Dehlinger; Dr. A. J. Bradley; Prof. Dr. E. Schmid; Dr. H. J. Gough; Prof. G. I. Taylor; Prof. Dr.-Ing. Ph. Theodorides; Prof. Dr. F. Kirchner; Prof. G. I. Finch; Prof. G. Aminoff; Dr. W. G. Burgers; Dr. M. Hansen; Prof. W. Köster; Prof. M. W. Broniewski; Par R. Castro; Prof. A. Skapski; Helge Löfquist; Dr. C. H. Desch; and J. Czochralski and O. Lubinkowski.

Light Metals and their Alloys

Thirteen papers are presented in this sub-group, which deal with several aspects of aluminium and its alloys and magnesium alloys. Some research on heat-treatment and age-hardening is discussed by Prof. Pierre Chevenard and Prof. Albert Portevin, while a theory concerning the mechanism of age-hardening in Al-Mg-Zn_2 alloys is given by Prof. M. Gotô and Sadajiro Kokubo. A noteworthy contribution is that by Prof. Dr. E. Azzarello, Dr. A. Accardo and Dr. F. Abramo, in which the results are given on an investigation on the chemical analysis of aluminium and its light alloys. These authors give two methods of analysis which have been developed, taken together it is stated that they permit of the accurate and systematic determination of Ag, Bi, Ca, Cd, Ce, Co, Cu, Fe, Mg, Mn, Ni, Pb, Sb, Si, Sn, Li, Zn, Zr, and the routine determination of W in all known types of aluminium materials (except those containing Mo), in which aluminium itself is the chief constituent.

The results of an investigation on the mechanical properties of aluminium crystals are presented by Prof. Dr. G. Welter. The influence of the grain of aluminium on the change of micro-mechanical properties—viz., on the limit of elasticity—has been studied. It has been ascertained that the purity of the material has a definite influence on the shape and orientation formed by the recrystallisation of the grain, thereby influencing the resisting properties. With the increase in diameter of the grain, the value of the resistance of the material is decreased; further, the influence gets stronger at first and then becomes much more uniform. Two qualities of aluminium were investigated: (1) 99·8% Al + (2) 99·5% Al.

Several alloys with useful properties and moderate strength are mentioned by S. L. Archbutt in a paper on progress in wrought aluminium alloys in Great Britain. Those containing 5 to 10% magnesium, with or without a small amount of manganese, possess good ductility with remarkable resistance to atmosphere and marine corrosion.

Alloys containing 8 to 12% silicon are highly ductile. A useful alloy consists of aluminium to which small amounts of magnesium and silicon in proportions obtaining in the compound Mg_2Si are added. In the hot-worked or annealed condition it can readily be formed into various shapes, and afterwards hardened by simple heat-treatment to give a tensile strength of 23·5 tons per sq. in., with 9% elongation in 2 in. Another medium strength alloy consists of aluminium with 4 to 5% copper and small amounts of silicon and manganese. In this alloy the variable solubility of the compound $CuAl_2$ is made use of to obtain hardening by heat-treatment after quenching. In sheet form a tensile strength of 25·5 tons per sq. in. with 15% elongation in 2 in. is obtained. For strength at high temperatures, an alloy containing 4% copper, 2% nickel, 1·5% manganese, developed during the war, has proved very satisfactory. By altering the proportions of the constituents in this alloy and adding a small amount of titanium, which has been found to produce grain refinement in cast aluminium alloys, another valuable series of alloys has been produced with high mechanical properties at ordinary and elevated temperatures. One of the features of alloys of this series is a high proof stress.

Recent progress in aluminium casting alloys is discussed by Dr. A. G. C. Gwyer and H. C. Dyson, in which attention is directed to new British specifications. Some B.S. and Air Ministry specifications have been issued, though the former have been redrafts of existing specifications. Among the latter, specifications covering alloys of the R.R. type have been issued—R R 50, R R 53, and R R 53B are covered; and similar alloys in which cerium replaces titanium as a grain-refining agent are also covered by another specification; another alloy of similar type contains chromium. A new specification covers "Aeral," a heat-treated alloy containing cadmium, which is added to improve corrosion resistance by its cathodic action; the alloy also has outstanding machinability. The only non-heat-treated alloys covered by new specifications are a modified silicon alloy of medium silicon content, and a silicon alloy containing nickel, which improves the elastic and dynamic properties. Heat-treated alloys are favoured not only because of their increased strength, but because the ratio of proof stress or elastic limit to the ultimate tensile strength is raised, while the ductility and toughness are superior to that of the as-cast alloys.

In discussing new applications, the authors refer to a development which may have far-reaching consequences—viz., the Cross engine. This has an aluminium piston working in an unlined aluminium cylinder. It is claimed that as a result of using a special type of piston ring the wear is less than in the normal steel or iron cylinder bore with an aluminium piston. Attempts are being made to develop aluminium alloy bearings, chiefly to save weight in aero engines, but there is as yet no commercial application of specific bearing alloys. Mention is also made of aluminium moulds for rubber goods, which are being used to a considerable extent on account of their clean surface, light weight, and thermal properties.

Duralumin has been studied in relation to the rotating beam endurance limit, and the results of tests are given in a paper by Dr. Eng. C. Pizzuto. The author states that the tempering of the cast alloy improves the static resistance, but has left the resilience and the endurance limit practically unchanged. He directs attention to the low qualities of these alloys when not forged or rolled.

As the result of work on Mg-Al and Cu-Al alloys and on Duralumin, Prof. M. Gotô and Dr. S. Sugiura discuss the modification of aluminium alloys and provide what is considered to be a basis for the explanation of the phenomena associated with their modification. The development of aluminium alloys and their properties forms the basis of an informative paper by Prof. Dr. A. Zeerleder, while E. H. Dix, jr., and Zay Jeffries discuss recent progress in aluminium alloys in America, in which they contrast the extensive use of heat-treated aluminium alloy castings in the United States with their more limited employment in the European industries. Of these, the aluminium-copper alloys still comprise the larger tonnage, although the aluminium-silicon-magnesium and the aluminium-silicon-magnesium-copper alloys enjoy substantial use, especially in parts which cannot be easily cast. In recent years the heat-treated aluminium 10% magnesium alloy has been supplanting the other heat-treatable compositions for applications requiring the maximum strength and shock resistance.

Magnesium Alloys

Two papers are presented which deal with magnesium alloys: one on the technology of magnesium alloys by Dr. G. Siebel, and the other on recent developments in magnesium alloys by Dr. J. L. Haughton. The first paper is concerned with alloys containing either one or more of the following constituents: Aluminium, zinc, manganese, and silicon, in which aluminium is the chief alloying element. During the last two or three years, however, states Dr. Haughton, several new alloys have been developed. In some of these aluminium is still the chief added element. Thus, an alloy containing 8% aluminium and 8% cadmium combines reasonable strength with good ductility. A more interesting series is that in which silver is added to the magnesium-aluminium alloys. Particular mention is made of an alloy which contains 8·5% aluminium and 2·5% of silver, to which small quantities of manganese and cadmium have been added.

Magnesium and many of its alloys lose strength very rapidly as the temperature is raised, and a considerable amount of work has been undertaken to find alloys which retain an appreciable proportion of their strength at temperatures up to 300° C. Some success has been attained, one of the most satisfactory alloys developed containing 10% of cerium and about 1·5% each of cobalt and manganese. This alloy is markedly inferior at room temperature to other alloys mentioned, but the fall of strength with rise of temperature is very much less.

Workability and Wear

This sub-group is divided into a consideration of workability and of wear, five papers being presented on the former and eight papers on the latter. Only one paper is presented on plastic deformation, that by Prof. Dr. E. Siebel, while four papers deal with cutting; internal stresses in machined surfaces by Dr. E. K. Henriksen; the turning, boring, milling and grinding of engineering materials is discussed by Prof. Dr. Ing. H. Opitz; Prof. Dempster Smith deals with cutting tools, in which he considers the development of high-speed steels and the testing of tool steel. Some results regarding the cutting of metals are presented by Dr. Ragnar Woxen, in which a tool life equation is given. The author shows how the cutting speeds are determined for a certain tool life, and corresponding to arbitrary combinations of cutting depths, feed and plan angles, and how the coefficients in the tools life equation are calculated. Prof. O. W. Boston discusse-cutting properties of metals which involve a number of complex, independent factors. The factors of major importance include the metal being cut, the cutting tool, the cutting fluid, the process or type of machine, the size and shape of the cut, and the general cutting conditions. Different results are obtained by changing any one factor. These variables are discussed.

Contributions to the subject of wear are made by F. le Chatelier and by Dr. Hans Meyer. Dr. F. P. Bowden and T. P. Hughes discuss the surface temperature of sliding metals and its influence on flow and wear; while experiments on the abrasion of metals are considered by H. E. Smith. Wear in special cases is discussed in papers by Von Oberbaurat A. Pohl, Dr. Seizo Saito, Dr. Masuhiro Suzuki, and Samuel J. Rosenberg.

In connection with this Congress, several interesting visits have been arranged.

Lubrication in the Cold-working of Metals

Slight alterations in the composition of a cold-rolling oil affects the operation to a marked extent, said Mr. R. Northmore, in a recent discussion before the Midland Metallurgical Societies, in which he dealt with a few of the applications of special oils in the cold-working of metals, a summary of which is presented in this article.

TO the uninitiated it is very difficult to appreciate how slight alterations in the composition of a cold-rolling oil could affect the operation to any marked extent, but Mr. Northmore had no doubt that many were familiar with the snags which could arise from the use of unsuitable oils. Without going too deeply into the subject one point is closely connected with the theory of metal rolling—that is, whether the success of the operation depends upon the allowance of some slip between the metal and the roll surface at some place between the point of intake and the dead centre of the rolls. Considerable difference of opinion exists regarding this matter. Many people seem to prefer the theory that the metal is in effect extruded away from the roll surfaces after the dead centre is passed, in which case, of course, no slip would occur. This factor is influenced by the choice of oil which allows the greatest possible amount of bite between the rolls and the metal, or, alternatively, a lubricant which allows the greatest possible amount of slip. It is probable that the majority of people would choose the oil giving the greatest bite, while extensive experiment seems to have proved this selection wrong.

Supporting this view, Mr. Northmore stated that in every case where he changed a rolling oil to one of lower surface tension and enhanced lubricating value, improved rolling had always resulted, and in some instances a really remarkable increase in extension of the metal had been obtained, indicating that there was much truth in the theory of slip. The same effect is especially noticeable on foil mills, where the metal is maintained under tension. On the other hand, a difficulty is encountered here as normal methods of reducing surface tension and improving lubricating value, such as the introduction of fats to a straight mineral oil, generally lead to complications with straining troubles in the annealing plant, a factor which is of growing importance, and which has recently been given much study.

Considerable experimental work has been carried out in the use of soluble oils on high-speed strip mills, a particular advantage claimed being their ability to keep roll surfaces cool despite the considerable frictional heat developed by the high rolling speeds. It is also felt in certain quarters that the use of a soluble oil solution of, say, 10-to-1 concentration instead of a straight rolling oil, minimises staining troubles in view of the smaller quantity of oil remaining on the strip passing to the furnace. It should not be overlooked, however, that the soluble oil must contain products more likely to decompose into bodies of comparatively high acidity under the temperatures used in the furnace than would be the straight rolling oil. The reduction obtainable is of importance in that connection, and the question of slip plays an important part, as though a soluble oil would permit the rolls obtaining a better hold on the metal, nothing like the same extensions were normally obtained as could be had with the straight product.

On a particular mill, rolling very light-gauge metal, extensions in the neighbourhood of two on each of three consecutive passes were obtained by the use of a specially selected straight rolling oil, but the best efforts with soluble oil solution, even at very high concentrations, had only resulted in extensions of a little over half that figure. Although the extra speeds obtainable would justify the inclusion of an extra pass to reach the final thickness required, a further difficulty was encountered in that the metal work-hardened during the preceding three passes to such a degree that it was almost impossible to obtain any further reduction on the fourth operation, and the introduction of an annealing process between these two passes would not seem justified at that stage.

It is, of course, possible to obtain high reductions with a soluble oil by employing a very drastic tensioning device at the feed end of the mill to impose a drag on the strip, but, in such circumstances, the rolls invariably tend to pick up metal from the strip and reduce the quality of the finish. On the question of finish, however, under normal conditions of rolling, the finish obtained with soluble oils was remarkably good, despite the very much higher speed of the operation.

Much work has been carried out recently with experimental dopes as surface tension-reducing agents, and whilst from a laboratory point of view these dopes are effective, under practical conditions they are not too successful. Apart from that, their usually rather low solubility in mineral oils, particularly at low temperatures, is a marked disadvantage. Another matter of considerable interest is the provision of suitable process lubricants for general stamping and press work, and in that category tube-drawing oils might be included.

Much diversity of opinion exists with regard to process lubricants for stamping and press work, and it is difficult to make any general remarks. Pressing and drawing compounds containing reasonably large quantities of fillers, such as powdered chalk, are usually preferable, although even these fall short of perfection in many instances. Extreme difficulty seems to be encountered immediately any tube-drawing operations are attempted, and under such conditions specially prepared blends of sulphurised or chlorinated products usually seem desirable for success. In tube drawing, particularly in the high tensile stainless steel, most of the difficulty seems to be due to the failure of the lubricant to maintain a film between the plug and the inner surface of the tube, rather than between the tube and the die, and success would probably result from a closer co-operation between the designers of the plugs and those concerned with the formulation of suitable lubricants.

It is generally agreed that a soluble oil provides the only really satisfactory method of lubricating and cooling the dies used in drawing non-ferrous wire, and an agreement had been reached as to the type of soluble oil which should be used for that purpose. The principal difficulty would seem to be the use of soluble oils, which form scum on slight contamination with acid, as it seems impossible to prevent the introduction of traces of acid from the pickling tanks, particularly in the early stages of the drawing operations, and if minute acidic contaminations result in scum formation, it is certain that the dies would quickly become clogged with copper dust and general debris, and result in the wire being broken.

Another problem is the provision of a suitable lubricant for use in the reduction of steel wire, which numerous attempts to solve have not given satisfactory results.

Here, again, it is probable that a soluble oil would be the most satisfactory solution, but it would seem necessary to provide one with either a very high viscosity mineral oil base or some other means of providing adequate lubrication for the more drastic work involved, and by so doing the inherent stability of the solution is automatically reduced. It is becoming increasingly popular to copper-sulphate steel wire before reduction, in order to facilitate its passage through the dies, but residual traces of copper remaining on the wire bring their own difficulties.

Corrosion Tests of Welded Low-carbon Stainless Steel

CONSIDERABLE controversy exists regarding the interpretation of results of laboratory corrosion tests of stainless steels. Three types of corrosion are usually recognised: (1) General, which is a simple chemical action over most of the surface; (2) pitting, depending upon surface conditions found in localised areas, and bearing no relation to structural features; and (3) intergranular—*i.e.*, localised corrosion progressing along grain boundaries. The unsatisfactory behaviour in service of supposedly corrosion-resistant alloys has been traced in part to intergranular corrosion that is associated with chromium-rich carbides localised in or at the grain boundaries. It is well established that heating within the temperature range of 550° to 800° C. accelerates the formation of these carbides, and hence increases the susceptibility to intergranular attack. During welding, certain portions of the metal adjacent to the weld are heated to within this range, consequently a welding test is frequently used to determine the susceptibility of material to carbide precipitation and intergranular corrosion.

Several laboratory corrosion methods have been recommended for testing materials that have been heated within the temperature range mentioned, and G. A. Ellinger and Leon C. Bibber have carried out an investigation,* designed to study these laboratory tests to determine their reliability for indicating the susceptibility to intergranular corrosion of welded low-carbon 18–8 steel.

The material from which the welded specimens were prepared was plate of a low-carbon corrosion-resisting steel of the 18–8 type, purchased for general welding tests. Arc welds were made with coated welding rods of about the same composition, and authors give the chemical compositions of the plate, welding rod and deposited weld metal, and also the type composition of the coating. Specimens consisting entirely of weld metal were prepared.

Three procedures were used for determining the corrosive attack: (1) Immersion in copper sulphate-sulphuric acid solution; (2) immersion in boiling nitric acid; and (3) immersion in boiling 6*N* hydrochloric acid solution. The first two methods are widely used in corrosion testing of stainless steel, the other is an arbitrary method to measure corrosion in a medium which does not permit stainless steel to develop its normal passivity.

In order to determine the effect of heat-treatment on the corrosion resistance, some of the specimens were heated for 1 hour at 980° C. and air cooled, others were heated for 1 hour at 650° C. and air cooled; the remainder were left in the "as-welded" condition. All heat-treating was done in an electric muffle furnace. The specimens were packed in sand, in small metal boxes, which were sealed to prevent oxidation.

Concentrated nitric acid at its boiling point has previously been used to produce intergranular corrosion in stainless steel. Evidence was obtained that this type of corrosion is the result of the selective attack by the acid on carbides that exist as networks at the grain boundaries. The cohesion between the constituent grains is destroyed and the material seriously weakened. Specimens of low-carbon stainless steel (0·06% of carbon) develop this type of intergranular corrosion only after the specimens have been heated so as to permit the formation of a carbide network at the grain boundaries. Without such heat-treatment the amount of the grain boundary carbides was not sufficient to render the steel subject to intergranular corrosion by boiling nitric acid.

A solution of copper sulphate in sulphuric acid has also been used to produce intergranular corrosion in stainless steels. It has been established by other investigators that the copper sulphate-sulphuric acid reagent does not destroy the carbides at the grain boundaries, but, instead, attacks the adjacent metal that has been impoverished in chromium through the formation of carbides. Low-carbon stainless steel (about 0·06% of carbon) is not subject to intergranular corrosion by this solution, presumably because the formation of carbides does not cause appreciable depletion of the chromium content of the metal adjacent to the boundaries.

Weld metal of approximately the same composition as the plate was not susceptible to intergranular corrosion in nitric acid or in a copper sulphate-sulphuric acid solution, regardless of heat-treatment. Carbides were not found in the grain boundaries of specimens that had been heated to facilitate their formation, but were localised in delta ferrite pools scattered throughout the matrix.

Low-carbon stainless steel, exposed to the action of 6*N* hydrochloric acid, lost weight much more rapidly than in either of the other solutions used. Weld metal that had not been heat-treated was attacked at a greater rate than plate metal. After heat-treatment, weld metal was attacked at a considerably lower rate than the plate. The attack is not intergranular, but is general over the exposed surfaces, and is severe and erratic. This reagent is of doubtful value for testing stainless steel of low carbon content.

* *Jour. Research*, U.S. Bureau of Standards, vol. 18, Jan., 1937. R.P. 963. Copies of this research paper may be obtained from the Superintendent of Documents, Washington, D.C., price 5 cents.

Tin Consumption Analysis

ACTIVITY in the principal tin consuming industries is at an appreciably higher level than a year ago, according to the March *Bulletin* of the International Tin Research and Development Council, world tinplate production in January, 1937, being 311,000 tons, against 275,000 tons in January, 1936, while the output of motor vehicles has increased from 473,000 to 501,000. World production of tin in January, at 13,660 tons, was at practically the same level as in January, 1936. The following are the permitted outputs of the chief producing countries for the first quarter of this year, with the quota at 100%: Malaya, 17,985 tons; Bolivia, 11,623 tons; Netherlands East Indies, 9,083 tons; Siam, 4,500 tons; Belgian Congo, 3,300 tons; Nigeria, 2,723 tons; French Indo China, 750 tons, making a total of 49,964 tons for these seven countries.

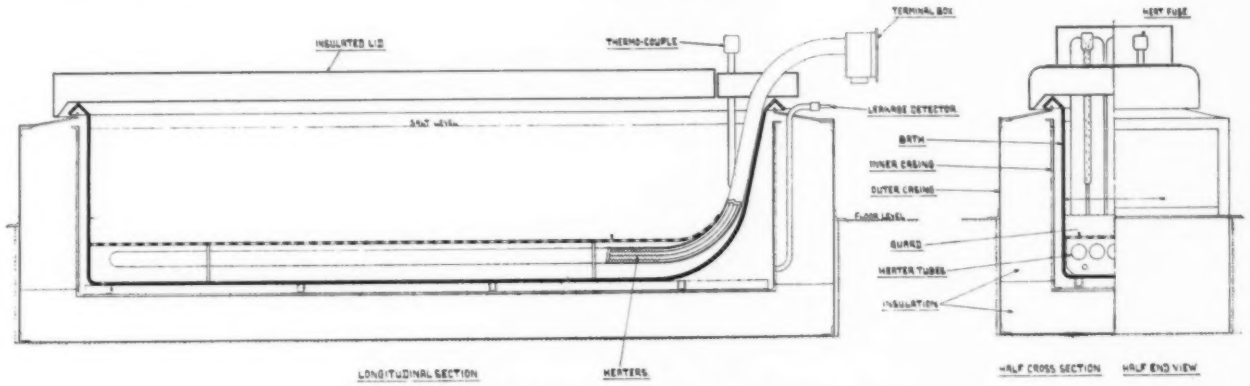
In the twelve months ended January, 1937, the consumption of tin in the U.S.A. increased by 19·5% as compared with the previous year, but in the United Kingdom the increase was only 1·8%. Consumption in Russia increased by 30·6%, and in France by 21·9%. Other notable increases are recorded for Czechoslovakia, 38·5%; Belgium, 28·2%; Poland, 42·1%; and Japan, 18·8%. The chief decreases occurred in Germany, 18·5%; Sweden, 17·4%; and India, 9·4%.

Recent Developments in Materials, Tools and Equipment

Kaercher Salt Baths

THE Kaercher salt bath is already in extensive use in Europe in the light metal industry. The essential feature of these equipments is the fact that heat is generated at the bottom of the bath, so that the salt is thoroughly stirred by convection currents and uniform temperature distribution ensured, without the necessity for passing through the thickness of the bath from the outside, as in externally heated equipment. The internal heaters used in this design impart heat very quickly and uniformly to the salt, therefore, and the bath itself is not subject to deterioration by external scaling or by severe temperature stresses.

A further point which may be stressed is the fact that the type of salt used for the heat-treatment process can be selected primarily with reference to its physical properties—minimum pick-up, evaporation, etc.—rather than with a view to its tendency to form an explosive sludge in the bath. With externally heated baths, the risk of explosion, when using certain types of salt, is appreciable since the sludge which is formed in the heat-treatment of aluminium alloys forms a blanket on the bottom of the bath and causes the latter to overheat to a point at which the sludge explodes. In this design, however, the sludge falls below the heating elements and is, therefore, not heated beyond the general bath temperature, under which conditions no explosion risk exists.



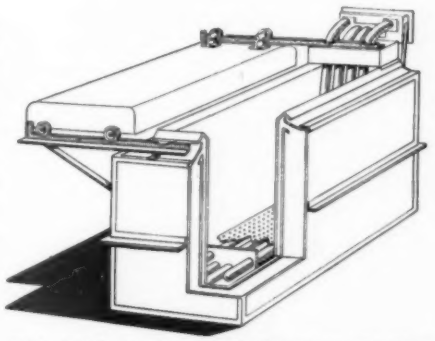
General arrangements of the rectangular type of Kaercher salt bath.

The foregoing arrangement is made possible only by the special design of the heating elements. This enables the heated portion to be kept in the bottom of the bath only, while enabling the element to be withdrawn from its sheath for repair or replacement on the infrequent occasions when this is necessary. With this object the element is made flexible, being constructed of spiralled nickel-chromium wire in special refractory spacers. A bath is normally fitted with a number of elements, and any one can therefore be withdrawn from its sheath for attention while the bath is maintained in production on the remaining heaters.

By minimising temperature gradient between the elements and the salt the life of the former is prolonged no less than that of the bath. A typical example is a Kaercher salt bath which has operated continuously for 6,000 hours without any detectable deterioration in either bath or elements. For the whole of the 6,000 hours, the bath was operating at or above 500° C. and the total output was approximately 1,000 tons of aluminium alloy.

The need of limiting temperature variations in the heat-treatment of aluminium and its alloys was a basic consideration in the design of these salt baths. The arrangement of the heating elements is such that tests have shown no variation greater than 3° C. between any two points in even the largest bath of this type. In addition, a comprehensive system of control and safeguards ensure close adherence to specified temperature conditions. They are fitted with a very complete system of safety devices. An alarm is operated and, if necessary, the heating elements switched off in any of the following contingencies :—

(a) Leakage of salt from the bath.
(b) Breakage of control thermocouple.
(c) Excess temperature through control failure.



Picioral view of the salt bath, showing construction.

The efficient and practical design of this salt bath, which has evolved from the intensive development work and wide experience of Messrs. G. Siebert G.m.b.H. of Hanau, is now available to British users in an equipment built entirely at the works of Birmingham Electric Furnaces, Ltd., and incorporating the features of robustness and reliability so necessary to satisfy service conditions. As stated in the last issue of this journal, Birmingham Electric Furnaces, Ltd., have acquired exclusive manufacturing and patent rights in these salt baths for Great Britain and the British Empire (excluding Canada), by an agreement with Messrs. G. Siebert. This salt bath is available in sizes to suit all output requirements, from small, circular, crucible type units to large rectangular baths, 30 ft. or more in length, and with loadings from 10 kw. to 500 kw. The general arrangements of the rectangular type are shown in the accompanying illustrations.

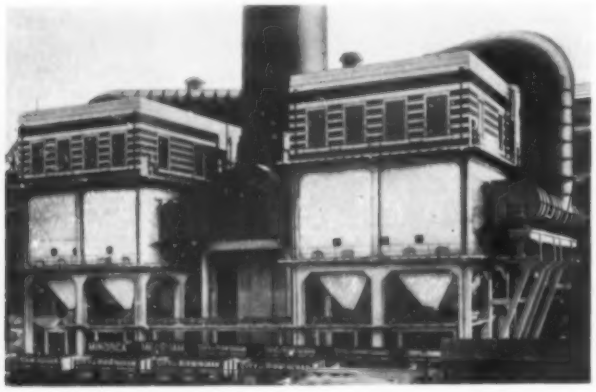
The bath is constructed of very heavy gauge steel plate of special quality ; there is generous space between the bath and outer casing which is filled with heat insulation ; temperature control is the automatic, indicating type, adjustable regulator operated from thermocouples immersed

in the salt; multi-point control is provided in large units. Power input is regulated by switches to give maximum rate of initial heating and close control at low temperatures and with light loads. The cover may be either sliding, hinged, or patented parallel link-motion types; each is heavily insulated and close fitting, with motor operation on the larger sizes.

Several hundreds of these equipments are in use throughout the Continent in aircraft and other works dealing with light alloys. It is noteworthy, however, that the first two of these baths will shortly be installed in this country, and it is believed that there is a wide field for which this equipment is particularly suited.

Electrostatic Separation for Coke-Oven Gas

AN efficient and economical method of completely removing the tar fog and dust present in coke-oven gases is the electrostatic, which results in the recovery of pure-white ammonium sulphate, a naphthalene of better colour, and a superior quality of tar with no trace of emulsification. Also a tar- and dust-free gas is obtained, which allows of operation with modern fine-nozzle types of automatically-controlled burners, and the whole pipe system is protected against tar troubles. In addition, thickening of the wash oil used in the benzole scrubbers is



Electrostatic precipitation plant at the Hams Hall power station, Birmingham.

presented with a considerable saving in wash oil, and an increased benzole production.

It is well known that the electrostatic method of dust separation was originated by Sir Oliver Lodge. The principle consists, it will be remembered, in causing the coke-oven gas or other gaseous medium containing solid and liquid particles to travel through towers or compartments provided with a series of earthed metal plates or pipes, known as collector electrodes. Between these plates or in the pipes, hang-rods or wires, acting as discharge electrodes connected to a high-tension (about 60,000-volt) direct-current electrical supply. Consequently, a corona discharge takes place from the wires, and all the solid and liquid particles are electrified and repelled towards the earthed collector electrodes. These are provided with motor-driven rapping hammers when solid particles are being separated, which fall into a suitable hopper below, while liquid particles merely run down to the bottom by gravity, and the gases pass on entirely free from particles in suspension.

One of the main advantages of the electrostatic method is the extremely high efficiency, with up to 99·9% separation of tar mist, which is not affected to any appreciable degree by the small size of the particles or the volume of the gas. Thus, particles, solid and liquid, below 10 microns (one micron equals one-thousandth of a millimetre) in size in the "mist" or "fog" stage are removed practically as easily as large particles, which is not the case with mechanical methods of removal.

Consequently, the sulphate of ammonia is pure white, and the tar does not emulsify because of the effective separation from water. For these and other reasons, such as considerable economies at the purifier beds and complete extraction of tar, dust, and water, the method is standard practice for treating the gases and vapours not only from the manufacture of metallurgical coke, but also town's gas, low-temperature carbonisation smokeless fuel, and such operations as briquetting and the baking of carbon electrodes.

Amongst the latest installations in course of construction by Lodge Cottrell Ltd. may be mentioned the new coke-oven plants of Dinnington Main Coal Co. Ltd., and the South Durham Steel and Iron Co. Ltd. (Cargo Fleet Iron Co. Ltd.), and the extensions to the existing detarrers of the same make at the works of Messrs. John Lysaght and Co., Ltd., Scunthorpe.

The separation is also easily and efficiently carried out when the gas is in the heated condition. Thus coke-oven gas may be allowed to enter the electrostatic separators at about 176–194 F. (80-90 C.), so that every trace of tar fog in suspension is removed at an early stage, an important advantage in many cases.

Another point also is that the final effluent is light coloured and considerably less toxic than usual, because of the effective removal of tar acids (higher phenols), along with the tar particles. In addition, the plant is relatively small in size, the back pressure is negligible, less than ¼ in. W.G., and the temperature of the gas is not reduced.

Because of the extensive experience that has been obtained, and the improvements in detail effected the method is also most economical, quite apart from the efficiency, the electrical power consumption being only of the order of 1 kwh. per 100,000 cu. ft. of gas, whilst the operation is also simple and free from continual supervision or appreciable maintenance costs. The high-tension direct current is obtained by means of a small transformer rectifier fed from the ordinary low-tension supply, usually including the firm's latest type of totally-enclosed oil-immersed metal oxide "static" rectifier for detarrer service.

The value of the method for blast-furnace gas cleaning is also well known, and installations are now in hand for the Park Gate Iron and Steel Co. Ltd., Ebbw Vale Iron and Steel Co. Ltd., and the Shelton Iron and Steel Co. Ltd., whilst one of the latest completed installations is at the Guest Keen Baldwins, East Moor Works plant in Cardiff, following upon Corby (Stewarts and Lloyds), Pretoria (South African Iron and Steel Co. Ltd.), and Jamshedpur (Tata Co. Ltd., India).

A New Raw Material for Industry

Exhibition of "Neoprene"

AN exhibition of "Neoprene" is to be held by Imperial Chemical Industries Ltd., at the offices of the Federation of British Industries, 21, Tothill Street, London, S.W. 1, from April 26th to May 1st.

In the past the search for synthetic materials of rubber-like properties has been merely with a view to finding a substitute for natural rubber. "Neoprene," however, has certain definite advantages over natural rubber which make it of great importance to industry generally. It is a product which is as easily handled in the factory as ordinary rubber, but is far more resistant to heat and to the deteriorating effects of vegetable, animal and mineral oils than natural rubber.

The exhibition will show articles which are being made from "Neoprene" and "Neoprene" composition for use in the engineering, aircraft, textile, printing, automobile and other industries. Lectures will be given at 4 o'clock each afternoon on various applications of the material.

Reviews of Current Literature

Metallic Corrosion Passivity and Protection

No one who has been concerned with work on the corrosion and protection of metals could fail to write with enthusiasm about Dr. Evans' new book on this subject. It combines many excellent qualities. It is an authoritative work of reference and at the same time a readable survey of the whole subject ; moreover, it is right up to date at the moment of publication. It is also of outstanding value in that, unlike so many comprehensive works that merely collect the facts and often leave the reader hopelessly bewildered as to what to make of them, Dr. Evans gives a reasoned view of all the phenomena with which he deals, and so guides the reader in a simple and interesting way through the intricacies of a difficult subject.

Naturally, the fundamental work on different aspects of corrosion and protective films, conducted over a period of many years by Dr. Evans, and his collaborators at the University of Cambridge, receives more extended treatment than that of other investigators ; but a fair hearing is given throughout to the work and views of others, including those whose opinions may not coincide entirely with those of the author. This seems a very proper attitude to adopt, as a writer can deal in a more inspiring way with what he has seen and done than what he has read.

The arrangement of the book is rather ingenious. Each chapter is divided into three sections, A, B, and C. In Section A the fundamental research on the subject matter of the chapter is described, and the general principles derived therefrom are discussed. In Section B these principles are applied to practical problems encountered in industry. These sections will be of the utmost value to industrial chemists, engineers, and metallurgists. Section C gives an elementary mathematical discussion of processes that can be represented by equations. While the C Sections are not difficult to follow by those who have not forgotten their elementary mathematics, the reader who does not care for equations and symbols can omit these relatively short sections without losing in any way the continuity of the book. The practical man will probably find the B sections most to his taste, but will appreciate them even better if he studies also the A sections.

In this way Dr. Evans has succeeded in producing a book that will appeal immediately both to the pure scientist and the practical man. Chapter XII, entitled : "Influence of Contacts and Crevices," may be cited as an example of how the scheme works. In this chapter Section A deals with fundamental research on corrosion at contacts with non-conducting substances, corrosion at contacts with other metals, and cathodic protection, and discusses fully the general principles involved. Section B discusses practical cases of corrosion occurring at crevices, rivets, welded joints, soldered joints, contacts between dissimilar metals, and the electro-chemical protection, and reviews them in the light of the foregoing principles. Section C is devoted to a condensed quantitative discussion of the electro-chemistry of bi-metallic systems.

To enumerate the subjects covered in the rest of the book would be tedious, and would not give an adequate impression of the vast amount of information contained. There must be few who could fail to find in it material bearing on their immediate corrosion problems. Among the many attractive sections of the book may be mentioned some of those dealing with the more practical aspects—especially the sections on public fuel policy and corrosion, the corrosion of buried pipes, condenser tubes, hot-water supplies, boiler problems, materials for the chemical industry, for building, for the food industries, for cooking, for the oil industry, and for use at sea, corrosion fatigue, protection by metallic coatings, paints and painting, and the testing of protective coatings. The corrosion of alloys, a subject on which relatively little has been written, is treated in the theoretical part. Some readers may be disappointed to find that bronzes are scarcely touched upon.

All research workers and those in charge of industrial operations concerned with metals, will require this book for constant use in their laboratories or offices.

By Ulick R. Evans, M.A., Sc.D.; published by Edward Arnold & Co., 41/3, Maddox Street, London, W.1. Price, 45/- net.

Brass Stampings

This book is chiefly devoted to a consideration of some of the uses, together with the properties, of brass and other copper alloy strip and sheet, materials which are widely used for the manufacture of pressings and other products required in engineering and general industry. It brings together, in a convenient form, much information that will be of interest to the general body of engineers and others who are concerned with the specification and ultimate use of such products. The information is presented in three sections, the first giving a general introduction in which it is emphasised that strip and sheet copper alloys may be obtained within close dimensional tolerances and possessing a very good finish ; the second section deals with some of the more fundamental processes employed in the manufacture of strip and sheet products ; while the third section gives a general description of the types and properties of copper alloys in strip and sheet forms. The book contains much useful practical information, especially to users of strip and sheet copper alloys. Copies of this publication may be obtained on application to the Copper Development Association, Thames House, Millbank, London, S.W. 1.

Drop Forging

This book is the sixth of a series of industrial textbooks edited by Dr. Percy Longmuir, designed to provide information in a direct, concise and condensed form, and, in view of the paucity of literature on the subject of drop-forging, this volume will be appreciated by both students and operators. The authors define drop-forging, and give brief information on the types of drop-forging hammers and trimming presses and on plant layout. Considerable attention is given to dies, the types of steel used, working temperature, conditioning treatment, and design, and a chapter is given to the consideration of die-setting, an operation which is not always given the importance it warrants.

Types of furnaces, fuels used and methods of heating represent a field beyond the requirements of this volume, but brief notes on heating are given which are useful to the drop-forger. Probably the most interesting and informative chapter is that which deals with the actual operations involved in drop-forging, trimming and subsequent manipulative operations. This chapter includes a series of illustrations and descriptive matter on the production of specific components by drop-forging. The authors discuss hot and cold inspection, and mention the economic value of hot inspection in keeping down the number of "wasters." The choice of die-block steel is briefly discussed, and also suitable trimming tool steels, while the final chapter is concerned with estimating, covering the weight of steel required per forging, the shape most suitable, and production figures.

The authors have not wasted words in their presentation of the subject, and in that sense are to be congratulated, but, probably it would have been profitable to include heat-treatment operations which now often form part of the production of drop-forgings ; however, this does not detract from the useful information given.

By C. Johnson and J. Warby ; published by Charles Griffin and Co., Ltd., 42, Drury Lane, London, W.C. 2. Price, 4s. net.

A.S.T.M. 1936 Book of Standards

THE American Society for Testing Materials has issued its 1936 Book of A.S.T.M. Standards. This triennial publication contains all the standard specifications, methods of test, recommended practices and definitions formally adopted by the Society. The issue is in two parts —Part I giving in their latest form all A.S.T.M. standards covering metallic materials ; Part II, all standards relating to non-metallic materials. Both parts aggregate 2,400 pages. In each part the specifications for a particular class of material are given first, followed directly by the test methods, definitions, etc. A complete subject index lists each standard under the principal subject covered, with the keywords in alphabetical sequence. This index, together with two tables of contents, one listing standards by the materials covered, the other in order of sequence of the serial designations facilitates the use of the book.

Of the 181 standards in Part I, 109 cover the ferrous metals, steel, wrought iron, pig-iron and iron castings and ferro-alloys, while 60 relate to non-ferrous metals, including aluminium and magnesium alloys, copper and copper alloys, lead, nickel, zinc, bearing metals, solder metal, deoxidisers, electrical-heating and electrical-resistance alloys. Twelve of the standards involve metallography and general testing methods.

The section devoted to ferrous materials covers structural and rivet steel ; boiler steels ; steel for welding ; concrete reinforcement steel ; commercial bar steels ; steel rails and accessories ; spring steel and springs ; steel blooms, forgings, and axles ; steel wheels and tyres ; steel castings ; steel tubes and pipe ; steel for high-temperature service ; zinc-coated steel and iron articles ; wrought iron ; pig-iron and iron castings ; and ferro-alloys.

The 60 standards relating to non-ferrous metals are grouped according to the following classfications :— Aluminum alloys ; copper and copper alloys (copper ingot ; brass and bronze ; copper and brass plates, tubes, rods, etc. ; copper wire and cable) ; lead ; nickel ; solder metal ; white metal (bearing metal) ; zinc ; deoxidisers ; electrical heating and electrical-resistance alloys.

Other standards in Part I cover grain size for classification of steels, metallographic testing of steel and of non-ferrous metals and alloys, radiographic testing of metal castings, thermal analysis of steel, Brinell and Rockwell hardness testing, tension-testing of metallic materials and definitions of terms relating to (1) metallography, (2) methods of testing, and (3) specific gravity.

Copies of the book in blue cloth binding can be obtained from A.S.T.M. Headquarters, 260, South Broad Street, Philadelphia, Pa., U.S.A. Prices : Either part, $7.50 ; both parts, $14.00.

Carnegie Scholarship Memoirs—Vol. XXV

THE studies presented in this volume are a further contribution to the accumulation of knowledge in various fields associated with iron and steel. They include an investigation on the running quality of liquid malleable iron and steel by Dr. Ing. Wolfram Ruff ; work on non-metallic inclusions in metallic melts by Dr. Roland Mitsche ; further studies of the wire-drawing process by Edgar L. Francis, M.Sc. ; a study of the formation of graphite in the pyrolysis of organic compounds by Wm. Hook, B.Sc. ; further contributions on some aspects of the fatigue properties of patented steel wires, which concern the effect of low-temperature heat-treatment on decarburised wires, by E. T. Gill, B.Sc., and R. Goodacre, B.Sc., Ph.D., and also a study of the endurance properties at high stresses, by R. Goodacre, B.Sc., Ph.D. ; a memoir on the effect of heat-treatment, ageing, and working upon the condition of carbon in steel, by Carl L. Shapiro, Sc.D. ; a further study of the thickness of oxide films on iron is given by H. A. Miley, M.A., M.S., Ph.D. ; and an investigation on the allotrophy of iron by Hans Esser.

Edited by K. HEADLAM-MORLEY, published by The Iron and Steel Institute, 28, Victoria Street, London, S.W. 1.

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Back Issues of "Metallurgia"

WE have received a request to supply the following copies of "Metallurgia"—

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also Indexes to Volumes 1, 2 and 8.

We are unable to supply copies of these issues, and would appreciate any reader, who may have copies of these issues, sending them along to us, the cost of which would, of course, be refunded.

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Business Notes and News

Aluminium Developments

At the recent general meeting of the British Aluminium Co., Ltd., the chairman, Mr. R. W. Cooper, M.C., J.P., made reference to a number of new developments. Mention was made of the Brytal process, which is a method whereby the high natural reflectivity of aluminium is rendered permanent; another new development is the production of a free-cutting alloy, of particular importance for automatic machinery; the perfection of a new process for the production of hollow bars of complicated shape; and a method for coating an aluminium alloy bar of any type with a thin pure aluminium.

Mr. Cooper emphasised the importance of the steel industry as an outlet for aluminium, not only on account of the activity in that industry, but also because of certain new developments: the introduction of a series of new and more powerful magnet steels containing 10–12% aluminium, and owing to a growing interest in the control of grain-size in many classes of steel, for which aluminium has been found to play a very important part. Though the amount of aluminium per ton of steel is small, the total quantity consumed in this industry amounts to a large tonnage annually.

Demonstration of Heat-treatment Plant

A demonstration of heat-treatment furnaces and pyrometer equipment is being held with the co-operation of the North Eastern Electric Supply Co., Ltd., at the power demonstration room, Carliol House, Newcastle-on-Tyne, from April 14 to 23, 1937 (excluding April 17–18), between 10 a.m. and 5 p.m. daily. The furnaces are manufactured by Wild-Barfield Electric Furnaces, Ltd., and include high-speed hardening furnaces, general batch-type furnaces, forced air circulation furnaces, and laboratory furnaces. Various types of pyrometers by the Foster Instrument Co., Ltd., are also on view.

In view of the growing appreciation of developments in heat-treatment equipment, this demonstration will be of interest, and readers are cordially invited to inspect the furnaces under working conditions.

New Colliery at Workington

The United Steel Companies, Ltd., will proceed with the sinking and equipment of a new colliery at Workington, to work the undersea coalfield lying to the west of the area occupied by the companies' works. There are approximately six square miles of undersea coal royalty, which it is intended to develop under this scheme, and the estimated reserves are very large. Shafts are to be sunk opposite the companies' iron and steel works and new coke ovens; they will be 21 ft. in diameter, and sunk to a depth of approximately 600 ft. from the surface.

The first 150 ft. of each shaft will be sunk through sand and gravel (which contains water) by the freezing method of sinking, and will be permanently lined with cast iron and concrete. The remaining 450 ft. of each shaft will be sunk through the ordinary coal measure rocks by the ordinary method of sinking, and will be permanently lined with brickwork. Coal will be wound in the downcast shaft only, which will be fitted to deal with 2,000 to 2,500 tons per day. From the underground shaft sidings four large roadways will be driven seaward, parallel to each other, for a distance of 1,500 yards, for the haulage of coal and transport of men, and for ventilation purposes. It is expected to cut the main band seam beyond a large downthrow fault to the west at this distance from the shafts. The main band seam is known to be fully 9 ft. thick and of good quality in this area. Several other well-known seams will also be available for working in this area.

The development of the colliery for full working will take some time, during which a considerable amount of employment will be given; when fully developed, this colliery should give work for more than 1,500 employees. It will be entirely electrically operated, and mechanical methods of mining will be applied as far as possible. This new colliery will be well situated for supply to the new coke ovens, for delivery of coal to the various inland markets by the L. M. and S. Railway system, and for shipment of coal at Workington Harbour and Docks owned by the company, which are only three-quarters of a mile away.

1937 Naval Programme

The first warships of the 1937 naval construction programme have been ordered. Subject to the settlement of certain points of detail, the Admiralty has placed the orders as follows: One aircraft carrier to Harland and Wolff, Ltd., Belfast; one escort vessel to John I. Thorneycroft and Co., Ltd., Southampton; and one tug to Fleming and Ferguson, Ltd., Paisley.

Though no details have yet been released, it is believed that the aircraft carrier will be of approximately 23,000 tons displacement, able to travel at high speed; in such case the value of the contract would be in the neighbourhood of £3,000,000.

Institute of Metals: Concession to Students

The Council of the Institute of Metals announces the temporary suspension of the entrance fee of one guinea hitherto payable by student members. Thus it now becomes possible for a qualified applicant, under 24 years of age, to join the student-member class on payment of only one guinea—the amount of the annual subscription.

The new scheme operates forthwith for a period of three years. Applicants whose names are submitted for approval at the next meeting of the Council—such names being received by the Secretary, the Institute of Metals, 36, Victoria Street, S.W. 1, not later than noon on April 29—may be elected at the beginning of July. As July marks the beginning of the Institute's new financial year, students then elected will enjoy a full year's membership in exchange for their guinea. They will receive exactly the same privileges as members (who pay an entrance fee of £2 2s. and an annual subscription of £3 3s.), with the exception that they will have no voting powers. The publications which they will receive each year include twelve issues of the Institute's *Monthly Journal* and three bound volumes of "Proceedings" and "Abstracts."

The Secretary will send the necessary forms and specimen journals to intending applicants for student or ordinary membership, who write to him at 36, Victoria Street, Westminster, London, S.W. 1.

Scrapping Obsolete Blast-furnaces

Five old furnaces at the Langloan Iron Works, Coatbridge, have been sold for dismantling. Six units of the Coltness Iron Co., at Newmains, are scheduled for destruction, and it is believed that seven old furnaces at Glengarnock Iron and Steel Works of Colvilles, Ltd., are also to be demolished. Dismantling of obsolete blast-furnaces in Scotland is probably due to the acute local demand for scrap iron. It is considered that a scrap yield of 800 to 1,000 tons would be obtained from them.

The destruction of the redundant Scottish blast-furnaces would mark the end of an era in the industry. The Scottish blast-furnaces were built to reduce the easily smelted black band ores mined in the district. The fuel used was hard splint coal, from which it was possible to extract by-products from the blast-furnaces. The sale of by-products, including tar, oil, and various chemicals, gave a manufacturing credit of about 8s. per ton of pig-iron produced. Splint coal resources decreased, and the development of competitive chemical industries reduced the credit from the above figure in 1920 to almost nothing a few years later. Most of the Scottish blast-furnace units went out of commission, and at one time only one was in blast. Recently there has been a partial revival, and fifteen units are in operation. Coke is the fuel now used, and the use of local iron has been limited by the coke supplies available in the district.

The removal of the old furnaces which still stand in large numbers in Lanarkshire and Ayrshire opens up the whole question of the future of the Scottish pig-iron trade. Since the district no longer enjoys peculiar local advantages in the shape of easily smelted local ore and by-product recovery direct in the blast-furnaces, it is thought that future developments will depend on the production of special irons.

Personal

Mr. R. Waddell, who was for 18 years General Manager of Messrs. Brown Bayley's Steelworks, Ltd., Sheffield, has joined Messrs. Campbell and Gifford, Consulting Engineers, 17, Victoria Street, London, S.W. 1.

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Chinese		65	16	0
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Solid Drawn Tubes	lb.	0	1	1¾
Brazed Tubes	,,	0	1	3¼
Rods Drawn	,,	0	1	0
Wire	,,	0	0	11
*Extruded Brass Bars	,,	0	0	7½

COPPER.

Standard Cash		£63	15	0
Electrolytic		67	0	0
Best Selected		68	0	0
Tough		67	10	0
Sheets		100	15	0
Wire Bars		69	5	0
Ingot Bars		69	5	0
Solid Drawn Tubes	lb.	0	1	3¼
Brazed Tubes	,,	0	1	3½

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‡Tungsten Metal Powder	lb.	£0	5	1½
‡Ferro Tungsten	,,	0	5	0
Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.				
NOMINAL: 2–4% Carbon, scale 11/– per unit	ton	30	10	0
NOMINAL: 4–6% Carbon, scale 7/– per unit	,,	22	7	6
NOMINAL: 6–8% Carbon, scale 7/– per unit	,,	21	12	0
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§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steelwork. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/– per unit	,,	33	0	0
Guar. max. 1% Carbon, scale 12/6 per unit	,,	36	0	0
§Guar. max. 0.5% Carbon, scale 12/6 per unit	,,	37	10	0
‡Manganese Metal 97–98% Mn	lb.	0	1	3
‡Metallic Chromium	,,	0	2	5
§Ferro-Vanadium 25–50%	,,	0	12	8
§Spiegel, 18–20%	ton	8	5	0
Ferro Silicon—				
Basis 10%, scale 3/– per unit	ton	8	5	0
20/30% basis 25%, scale 3/6 per unit	,,	11	2	6
45/50% basis 45%, scale 5/– per unit	,,	11	15	0
70/80% basis 75%, scale 7/– per unit	,,	16	15	0
90/95% basis 90%, scale 10/– per unit	,,	28	17	6
§Silico Manganese 65/75% Mn., basis 65% Mn.	,,	15	0	0
§Ferro-Carbon Titanium, 15/18% Ti	lb.	0	0	4½
Ferro Phosphorus, 20–25%	ton	22	0	0
§Ferro-Molybdenum, Molyte	lb.	0	4	9
§Calcium Molybdate	,,	0	4	5

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S. Wales	£1	12	6	to	13	0
Scotland	—				1	8	0
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Furnace Coke—						
Scotland	—				—	
S. Wales	—				1	7	6
Durham	—				1	7	0

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*Gunmetal Bars, Tank brand, 1 in. dia. and upwards	lb.	0	1	1
*Cored Bars	,,	0	1	3

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N.E. Coast—				
Rivets		10	10	0
Best Bars		13	0	0
Common Bars		9	5	0
Lancashire—				
Crown Bars		10	10	0
Hoops	£10 10 0 to	12	0	0
Midlands—				
Crown Bars		10	10	0
Marked Bars		13	0	0
Unmarked Bars	from	9	7	0
Nut and Bolt Bars	£8 17 6 to	9	7	6
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†Sheet to 10 W.G.	,,	0	1	3
†Wire	,,	0	1	3½
†Rods	,,	0	1	4½
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Hæmatite No. 1	4	18	0	
Foundry No. 1	4	3	6	
,, No. 3	4	1	0	
,, No. 4	4	0	0	
Silicon Iron	—			
Forge	4	0	0	
Midlands—				
N. Staffs. Forge No. 4	4	3	0	
,, Foundry No. 3	4	6	0	
Northants—				
Foundry No. 1	4	6	6	
Forge No. 4	4	0	6	
Foundry No. 3	4	3	6	
Derbyshire Forge	4	3	0	
,, Foundry No. 1	4	9	0	
,, Foundry No. 3	4	6	0	
West Coast Hæmatite	5	3	6	
East ,, ,,	—			

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Zinc	18	0	0	
Aluminium Cuttings	74	0	0	
Lead	25	10	0	
Heavy Steel—				
S. Wales	3	10	0	
Scotland	3	6	0	
Cleveland	3	7	0	
Cast Iron—				
Midlands	3	5	0	
S. Wales	3	10	0	
Cleveland	4	2	6	
Steel Turnings—				
Cleveland	2	12	6	
Midlands	2	5	0	
Cast Iron Borings—				
Cleveland	—			
Scotland	2	2	6	

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,, ,, (Marine) ,,	8	17	6	
Angles, Scotland	8	7	6	
,, North-East Coast	8	7	6	
,, Midlands	8	7	6	
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Scotland, Sheets 24 B.G.	10	10	0	

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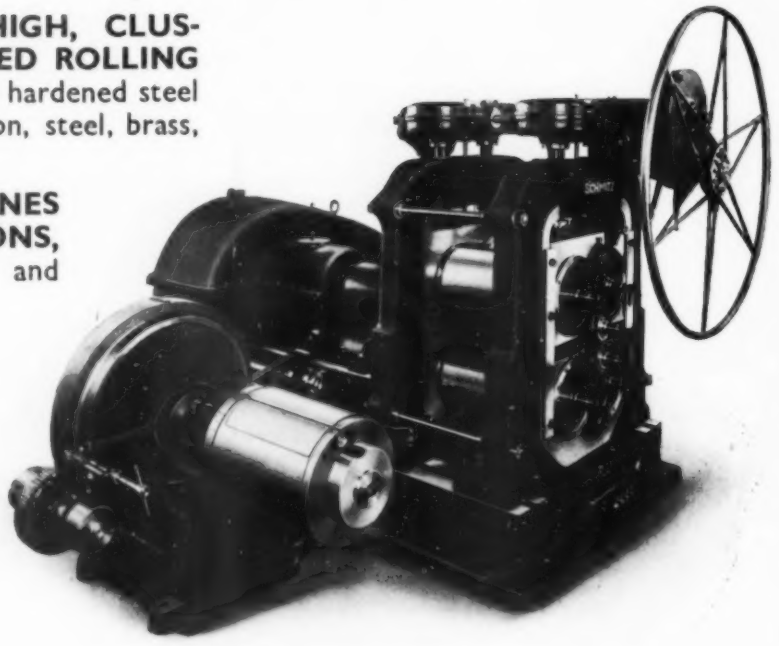

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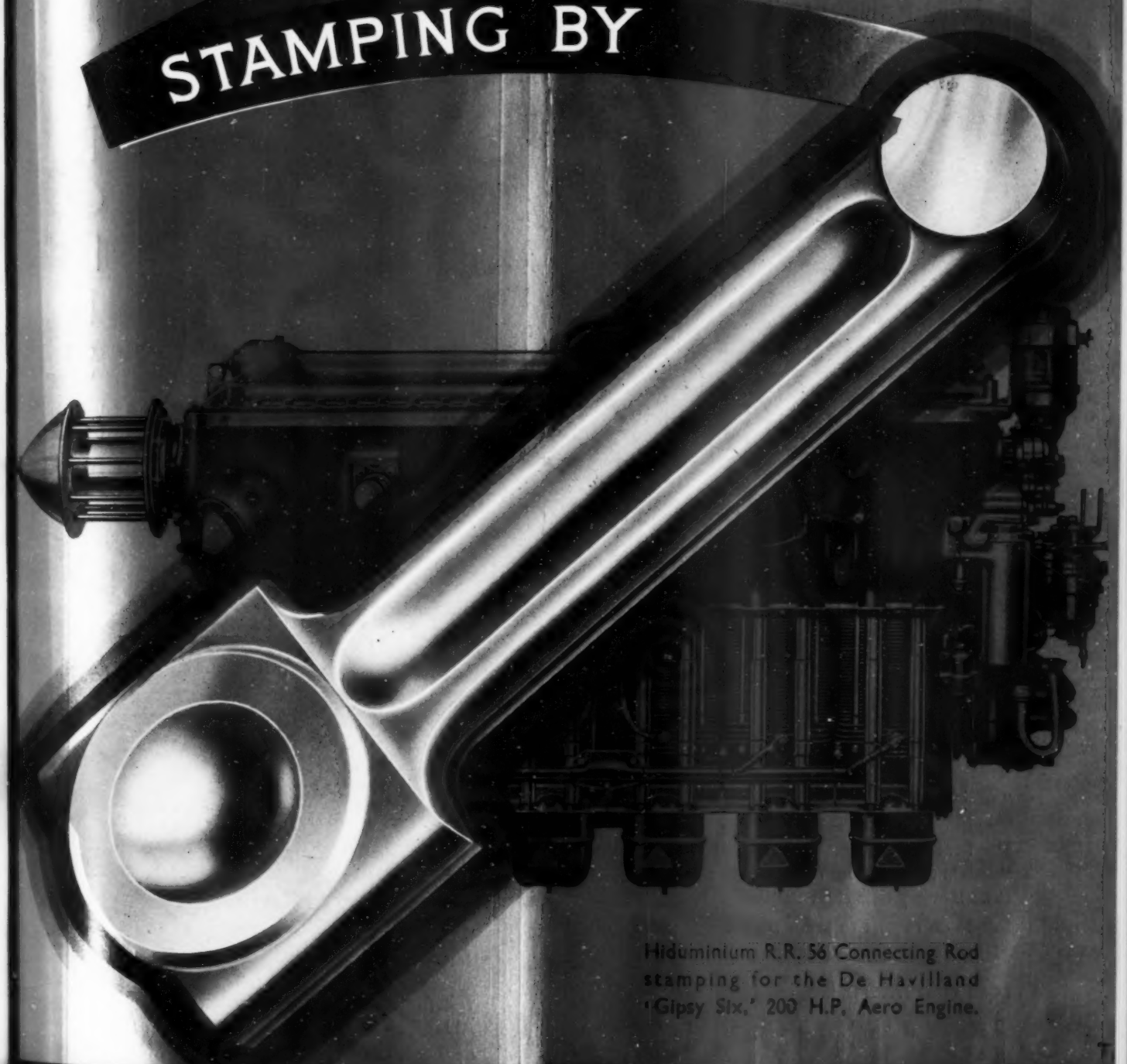

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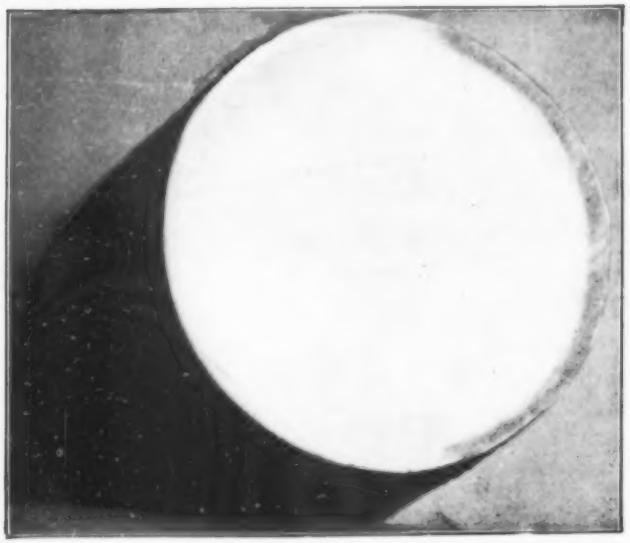

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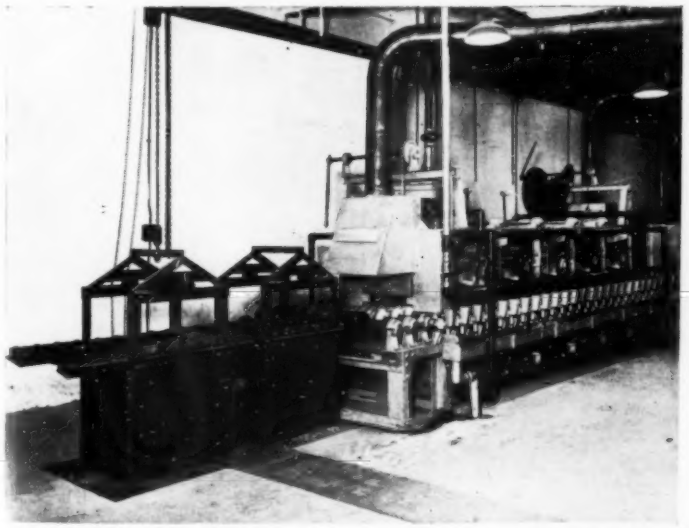

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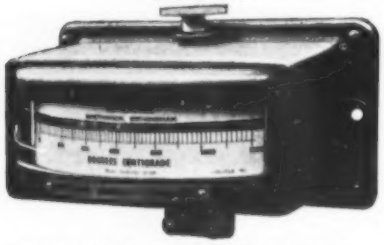

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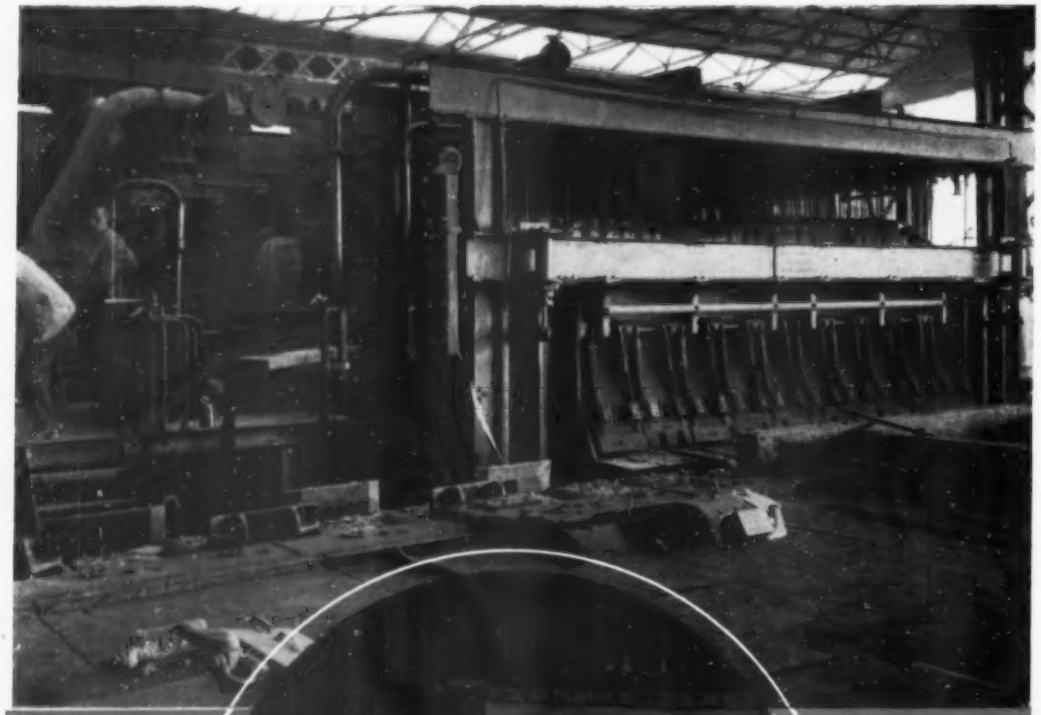

The continuous furnace shown in the above illustration is installed at the Cardiff Works of Messrs. Guest, Keen, Baldwins Iron & Steel Co. Ltd. It is used for heating the blooms for a 21-in. light section mill.

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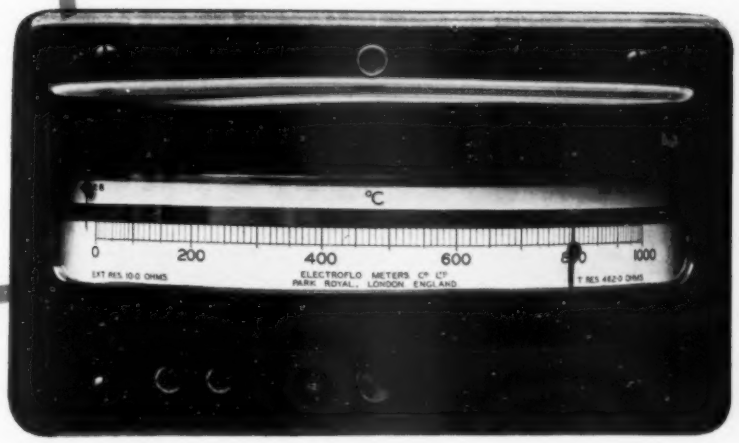

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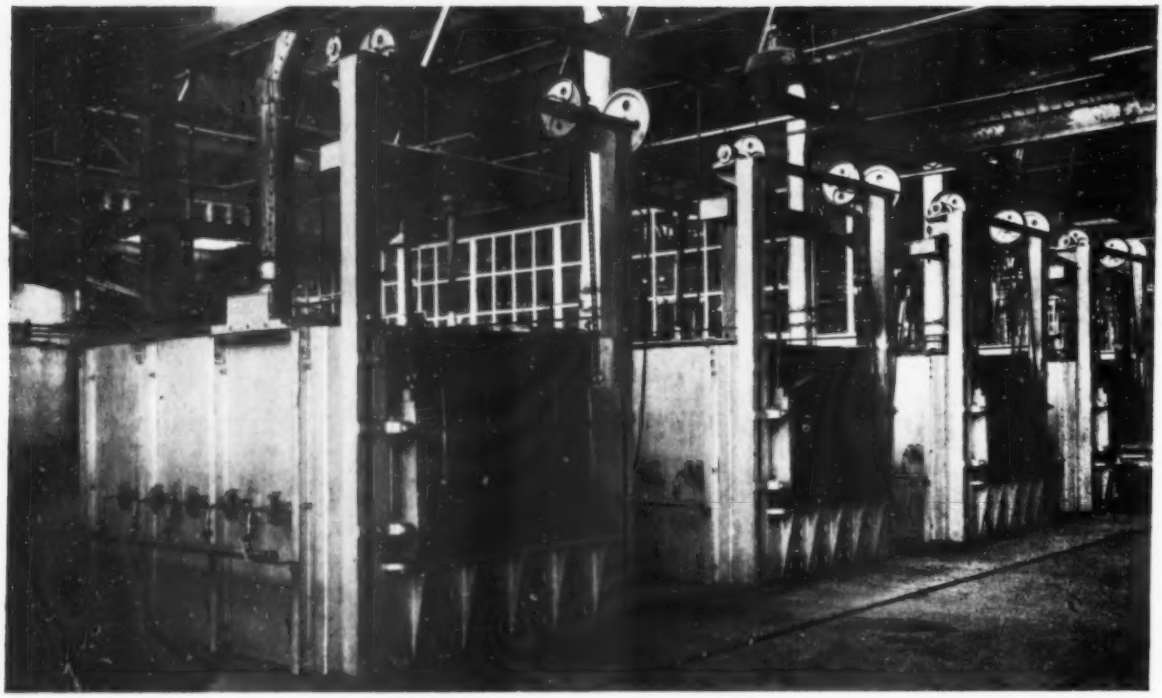

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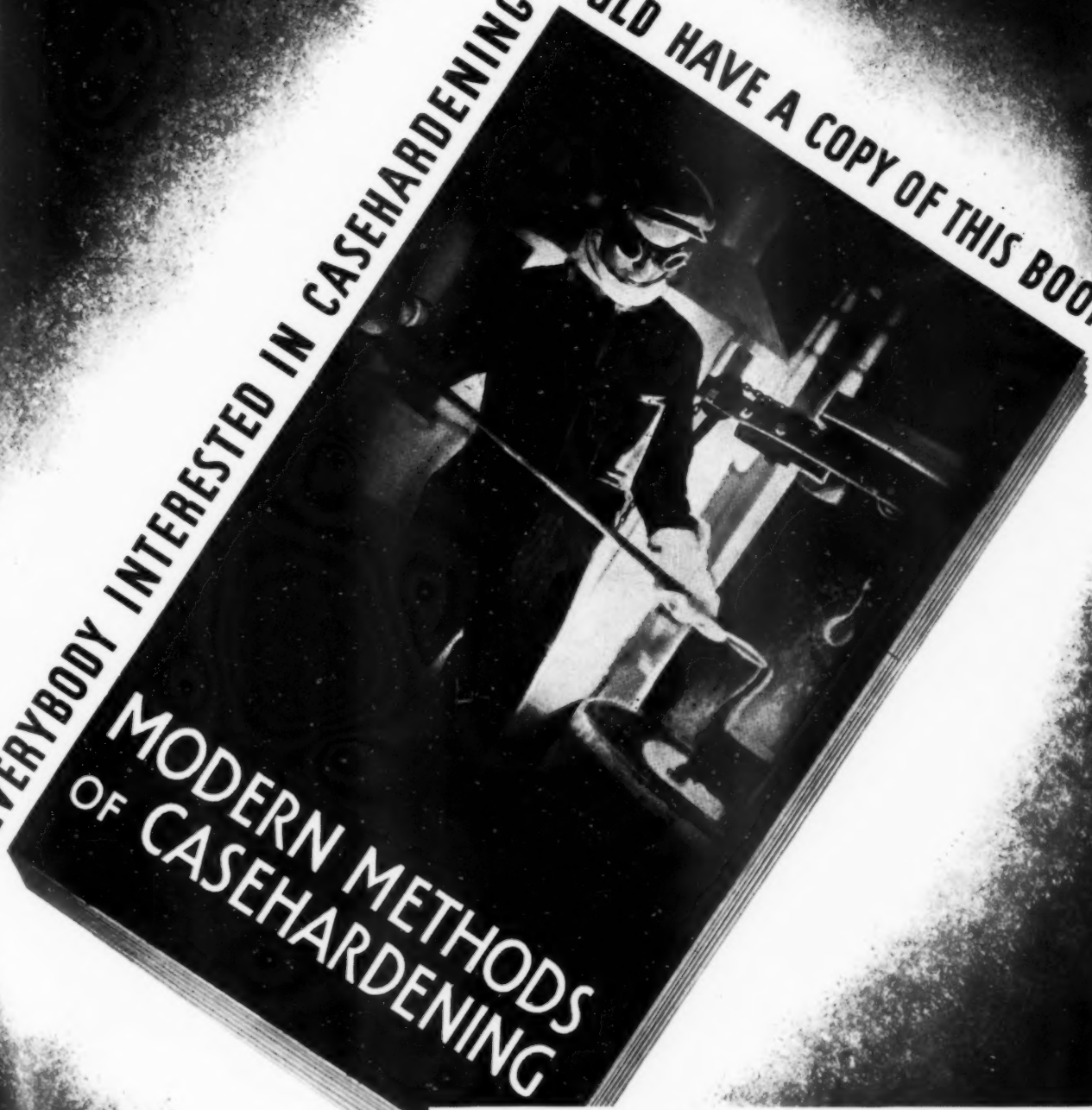

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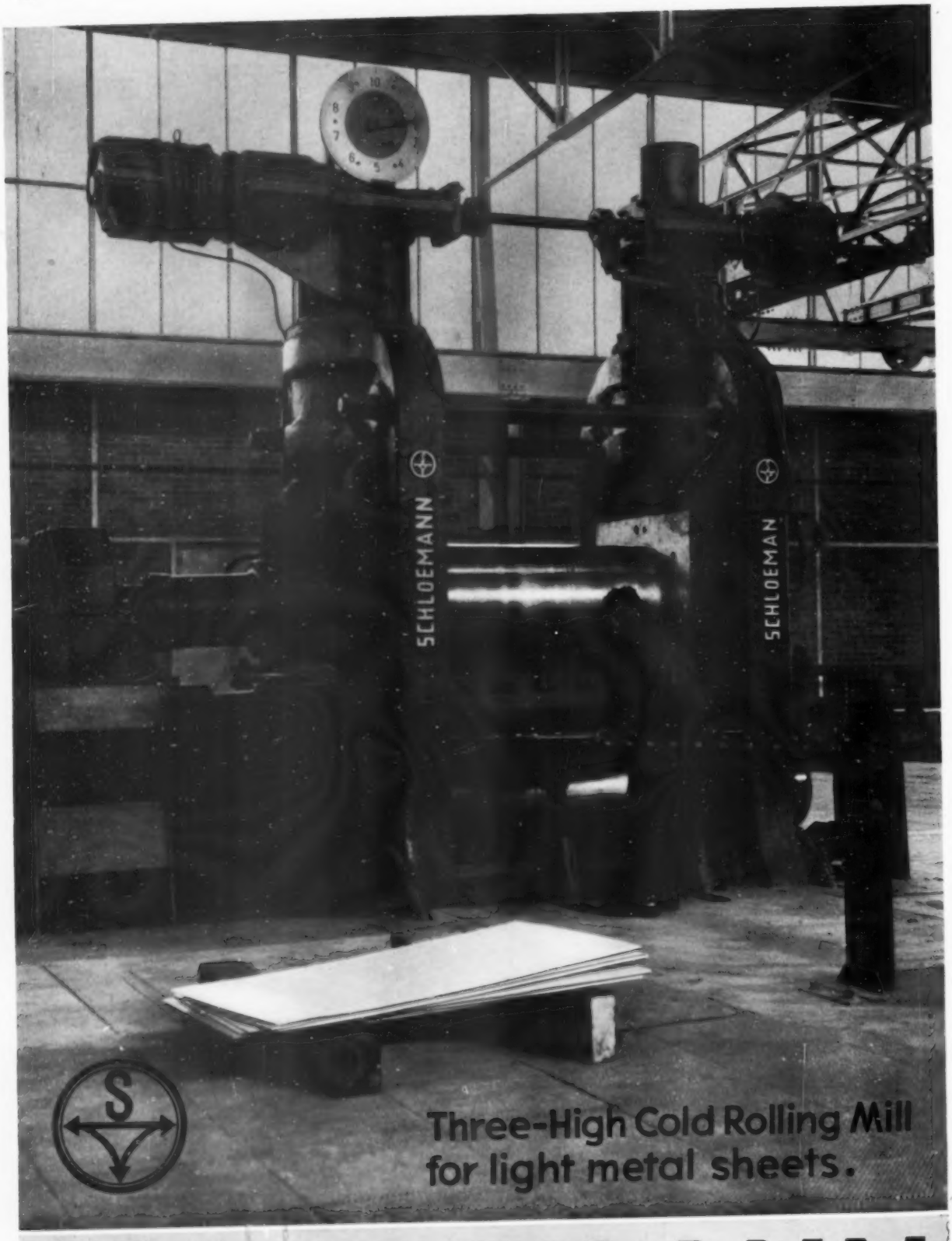

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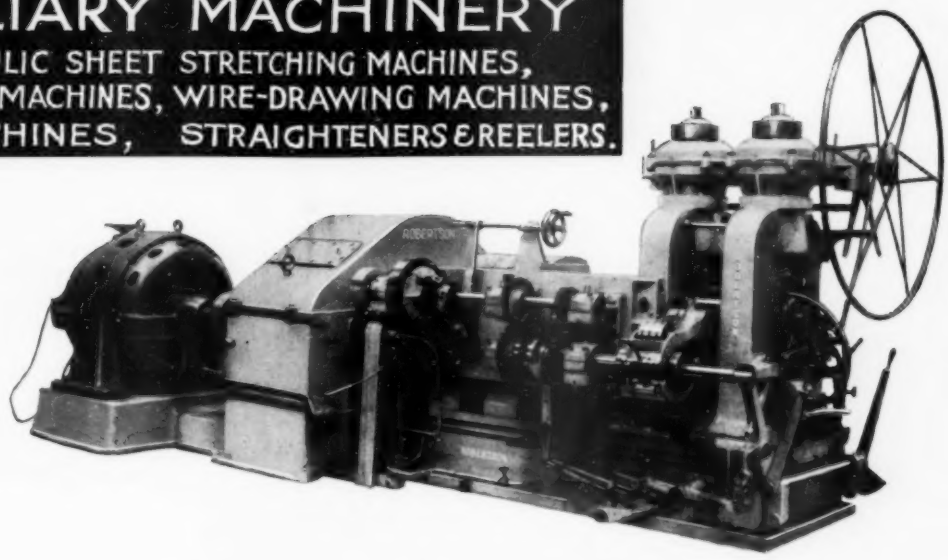

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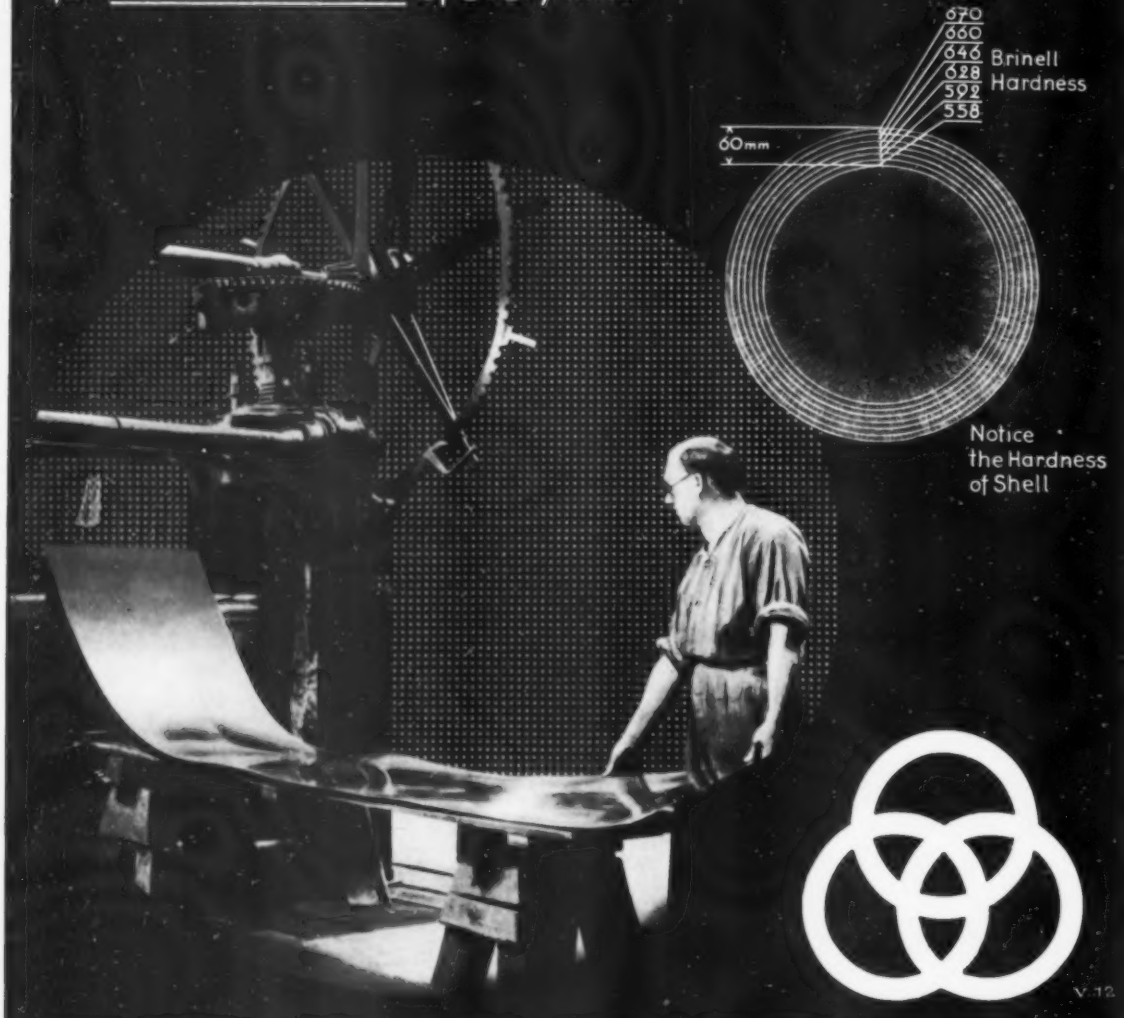

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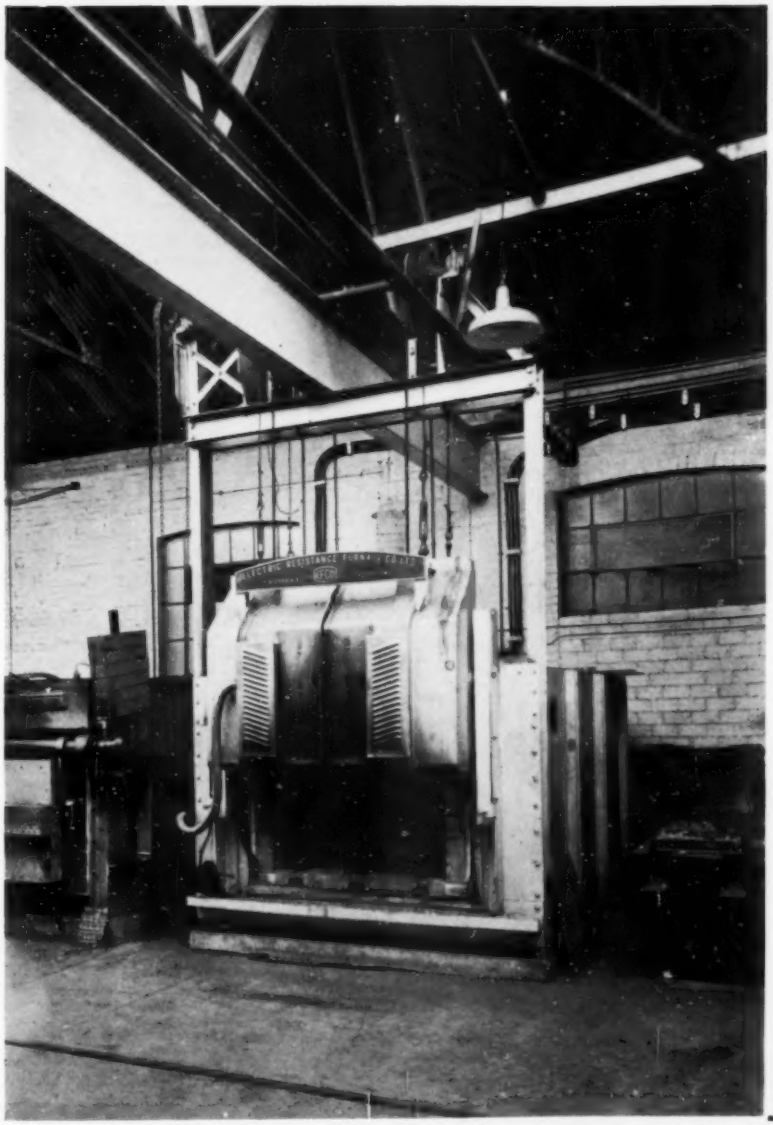

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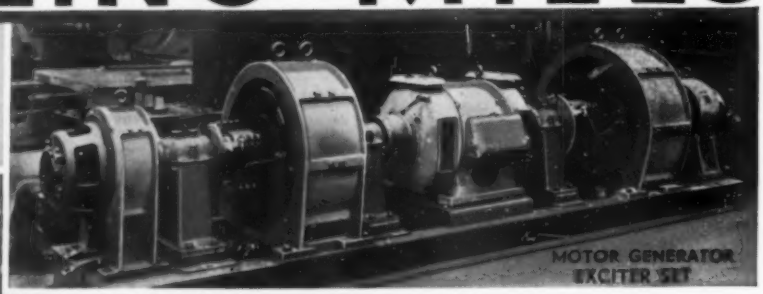

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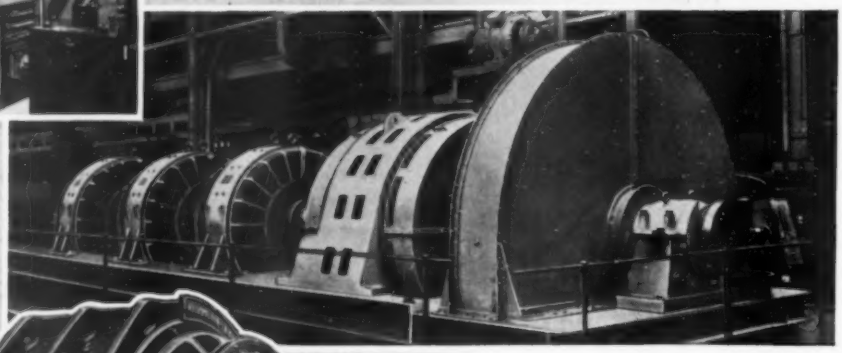

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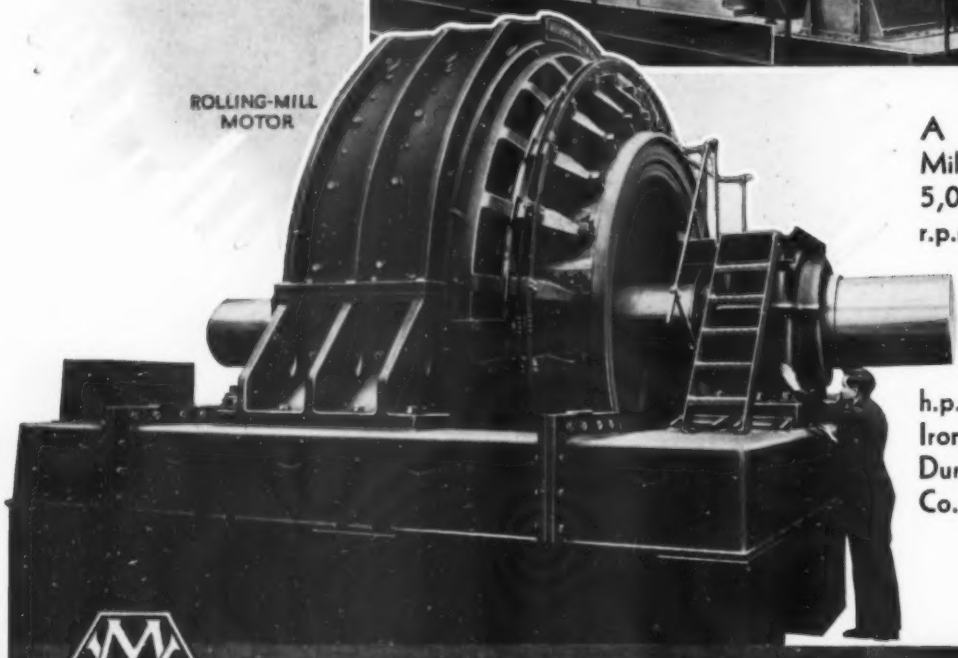

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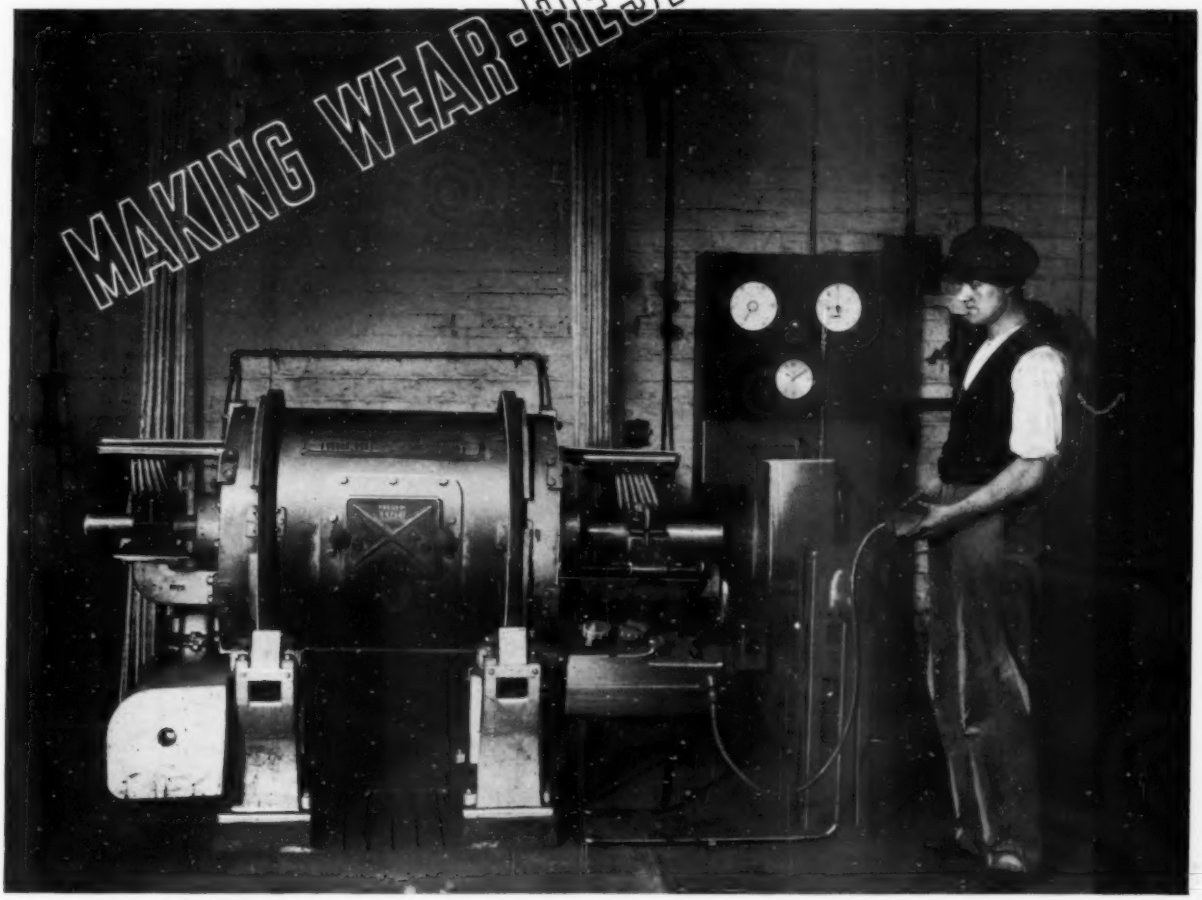

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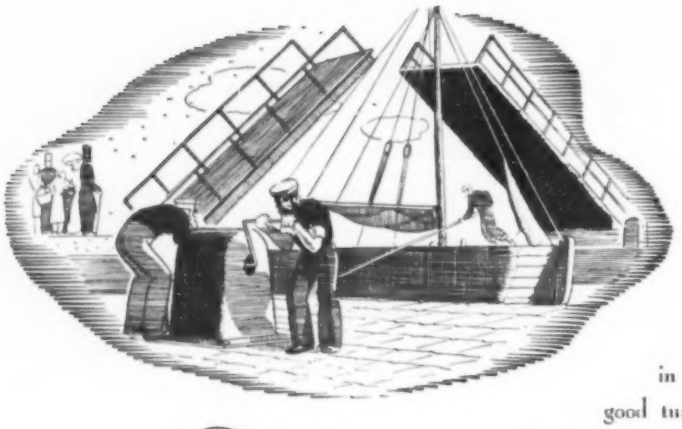

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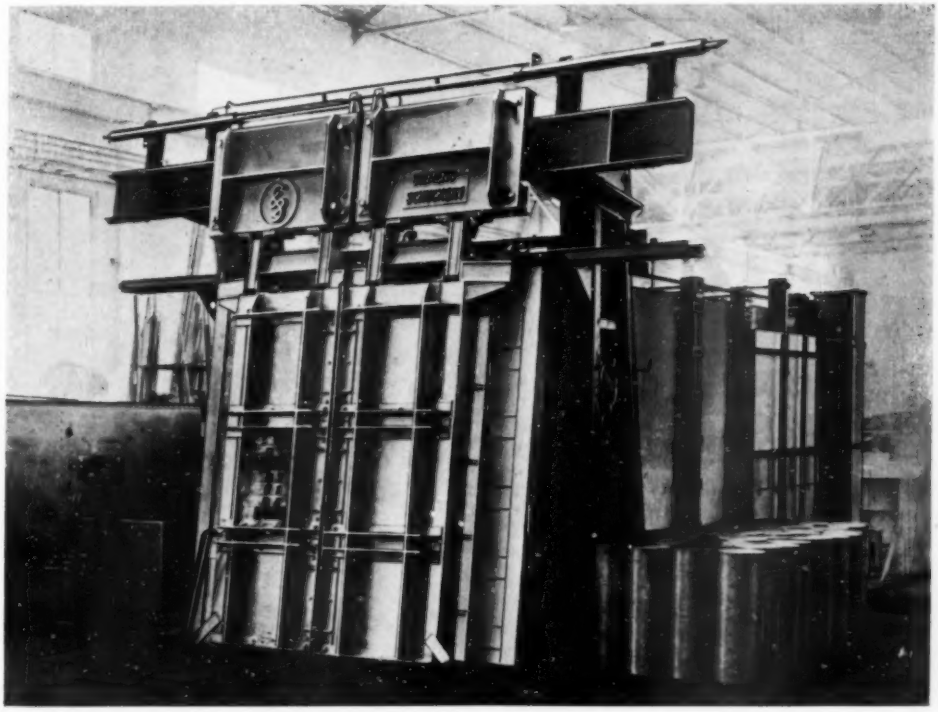

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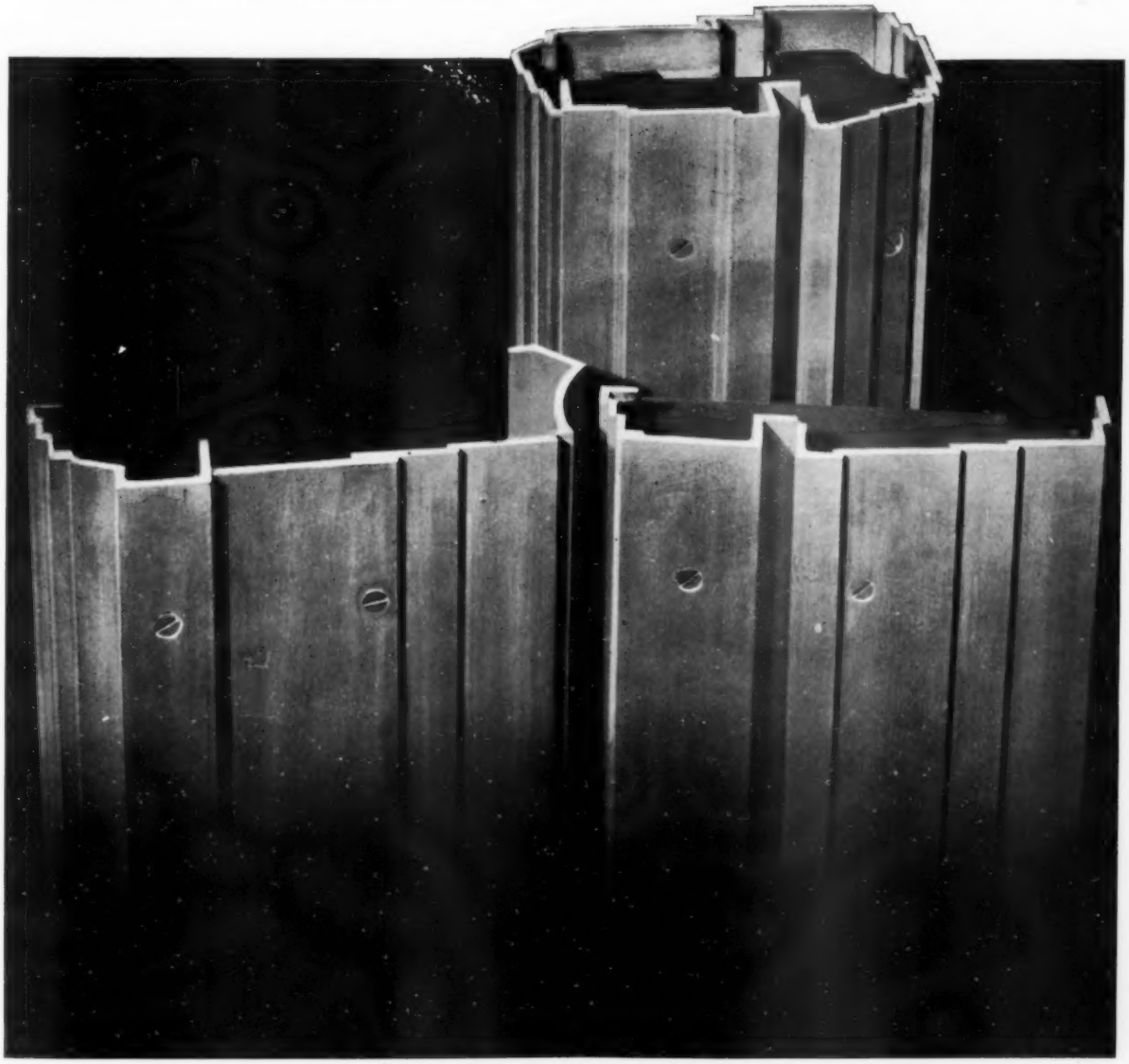

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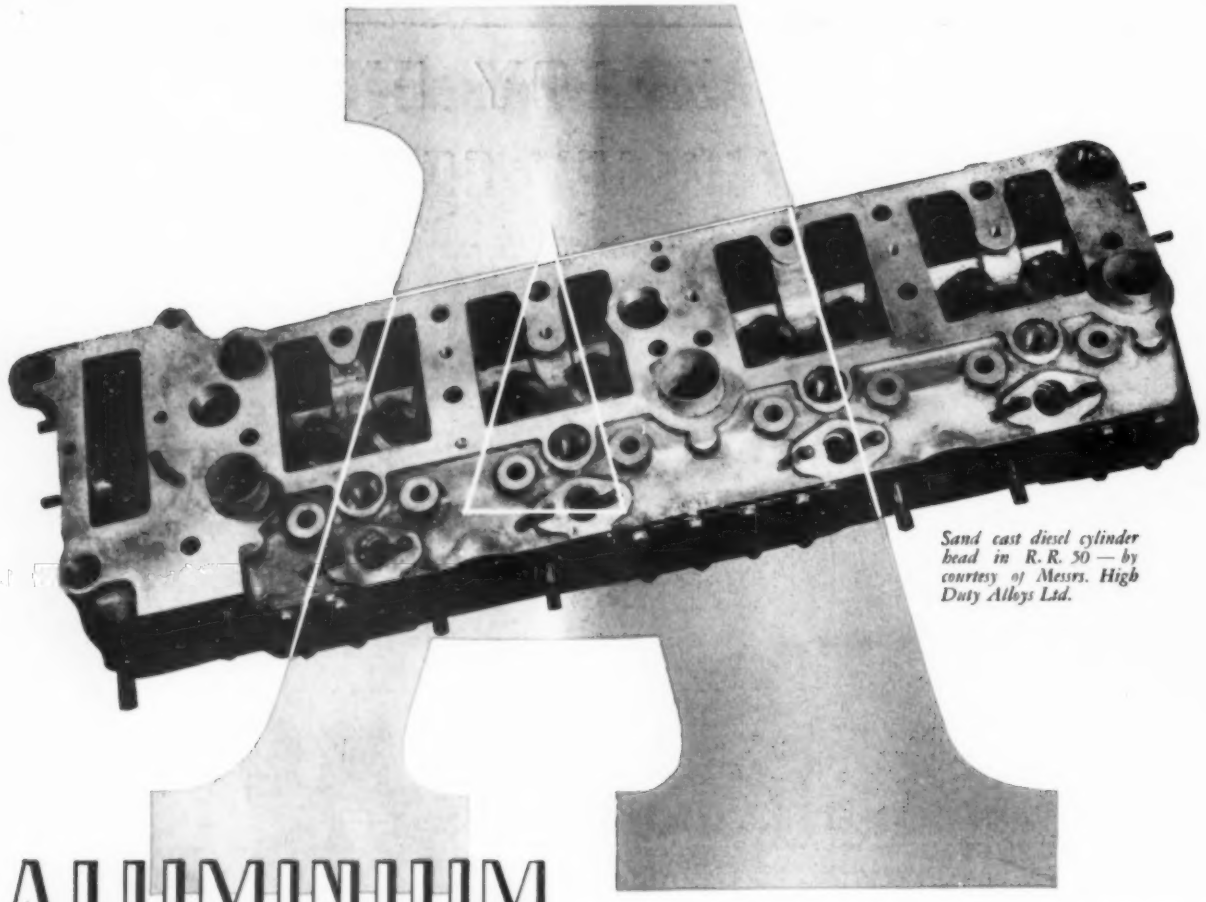

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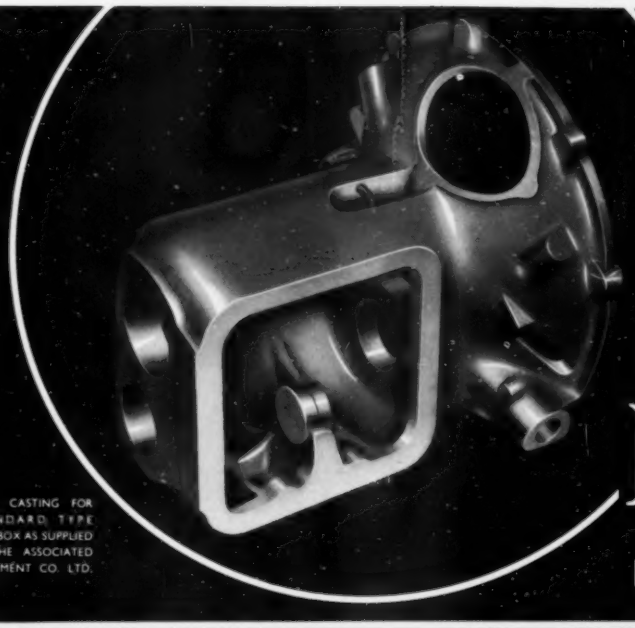

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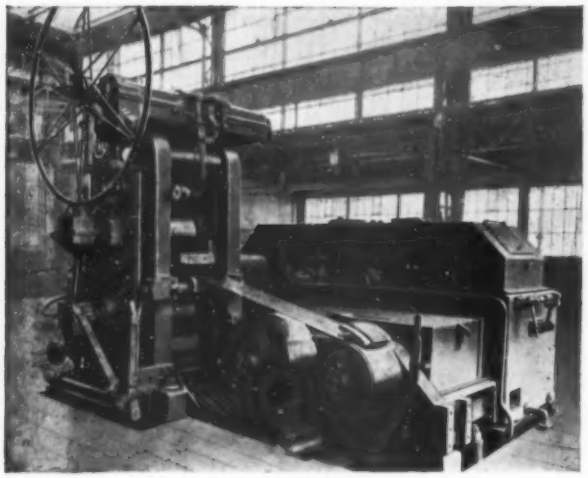

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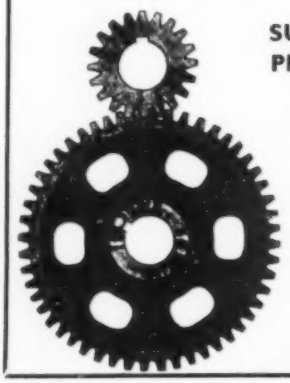

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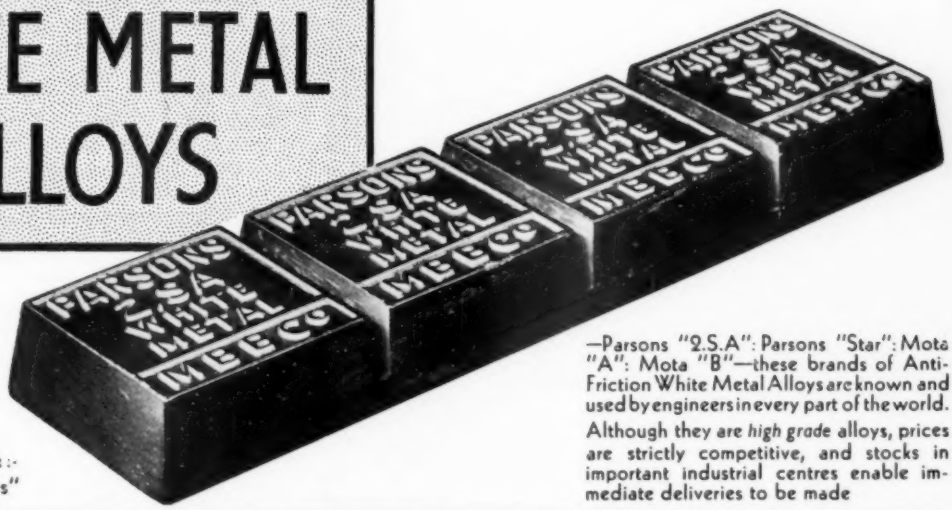

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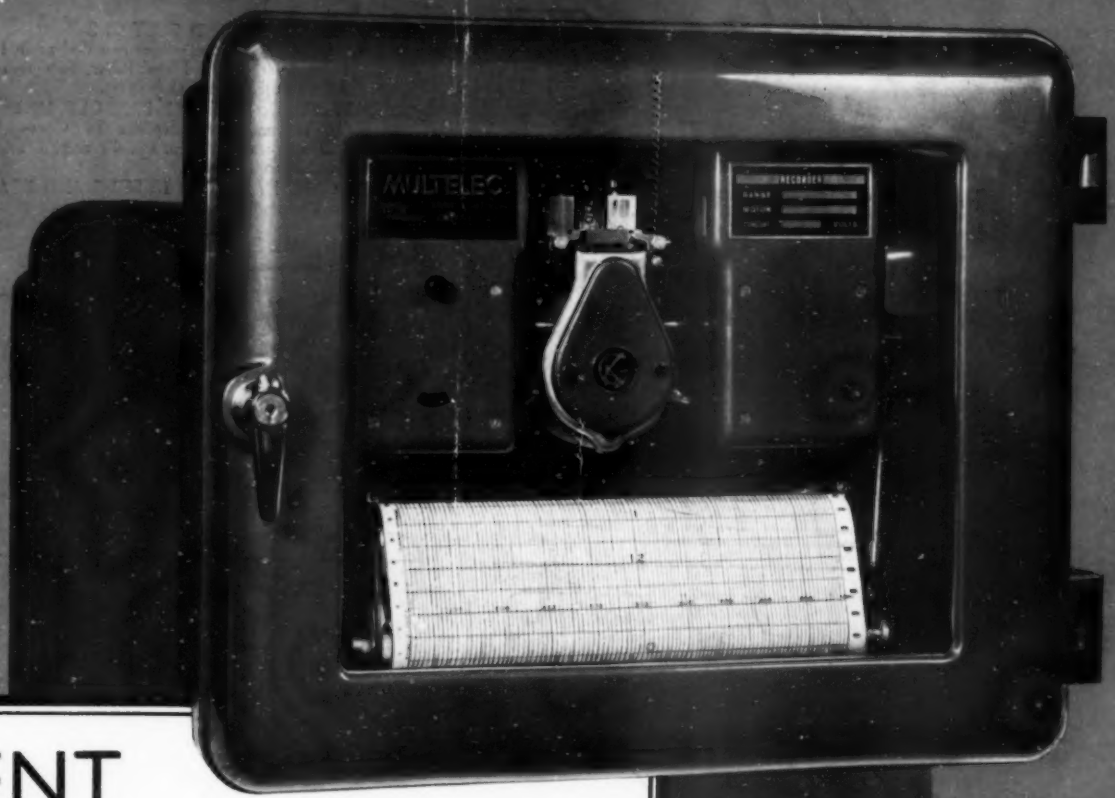

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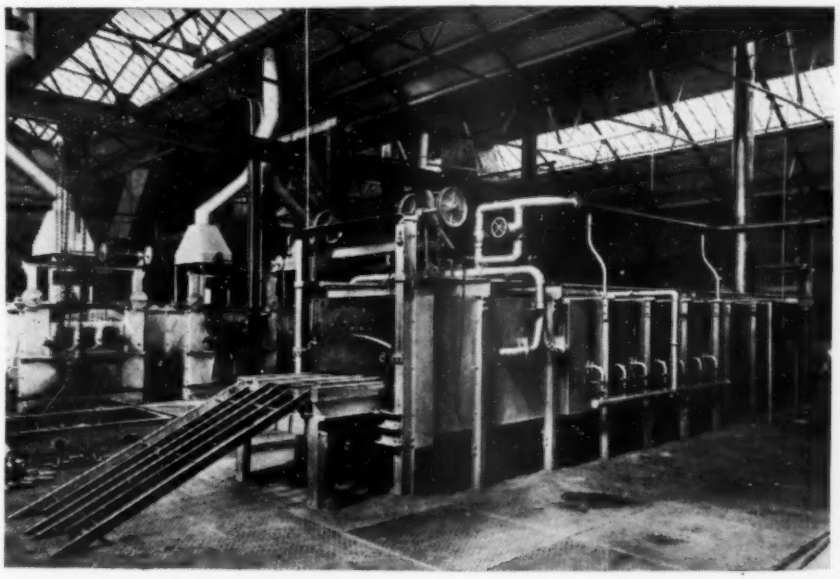
(From 'The Heat Treatment of Steel.')



NO requirements for the heat treatment of steel are more exacting than are those for the mass production of motor car parts. Absolute uniformity and reliability are essential. The desired mechanical and physical properties have to be consistently obtained. A form of heat has therefore to be used which can be accurately controlled and which also allows for the control of the furnace atmosphere.

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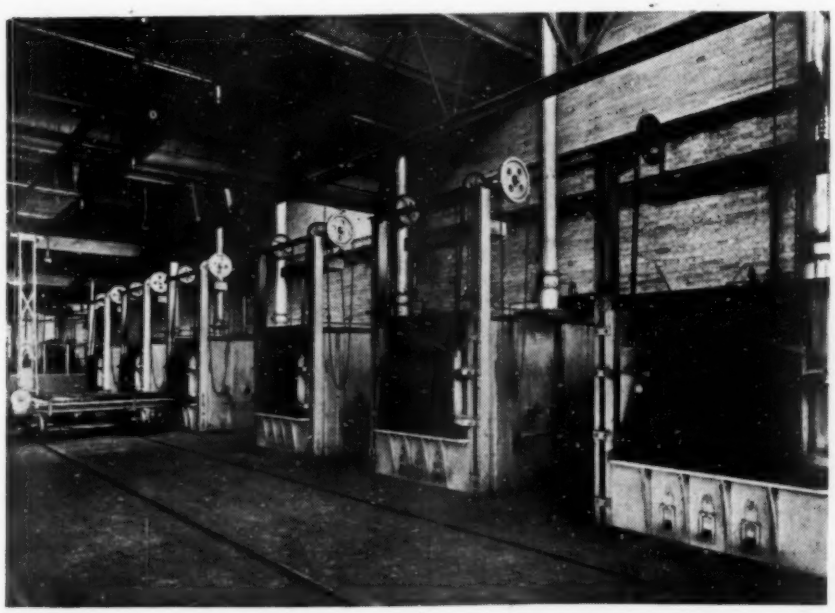

All interested in the heat treatment of steel should send for the invaluable treatise issued by the British Commercial Gas Assoc., of 28, Grosvenor Gardens, London, S.W.1. It is quite free. Among a mass of information the latest developments in furnace design are explained, and, in addition, no less than 23 actual installations are illustrated and described.

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Heat Treatment's Place in Mass Production

CONTINUOUS GAS-FIRED FURNACES AT THE FORD WORKS

(From "The Heat-Treatment of Steel.")

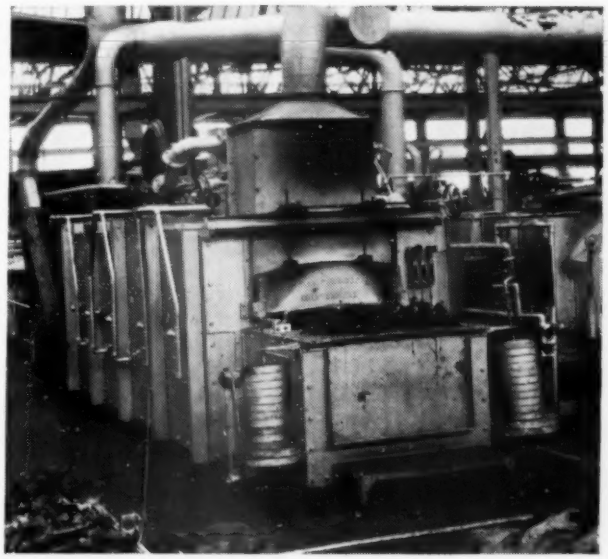
IT has not been so easy to apply continuous automatic processes to the heat-treatment of steel parts as it has to most other operations in the modern mass-production factory. But it has been done. With the help of an easily and accurately controlled source of heat and a little ingenuity a number of continuous heat-treatment furnaces have been produced, and are now in operation in this country. As is to be expected, the Ford Motor Company would make the utmost use of such furnaces, and their works at Dagenham have an interesting system of conveyor-furnaces for the hardening and tempering of forgings.

There is a hardening furnace of approximately 24 feet long, and is divided into three zones, in the second and third of which the temperature is automatically controlled. The forgings pass through the furnace on a conveyor-belt of heat-resisting steel, and are delivered by means of a chute into the quenching tank. They are then picked up by means of a slate conveyor, and delivered to the operator at the tempering furnace.

The corresponding tempering furnace is also 24 feet long, and, like the hardening furnace, is divided into three zones, but the temperature is automatically controlled in all of them. The forgings are carried through the furnace on a similar conveyor belt and delivered by means of a chute on to the main floor of the heat-treatment shop.

The capacity of this installation is approximately one ton of miscellaneous forgings per hour, but the rate of travel through the furnace can be altered by means of a variable-speed motor in order to give the required soaking time for the particular type of steel being treated.

For normalising, a walking beam furnace of similar size and throughput is used. This, too, is divided into three 8-feet zones separately controlled.



A hardening furnace at the Ford works.

Advantages of Gas Firing

So the whole process of heat-treatment is practically continuous and automatic. How has this been made possible? The first essential, of course, was a form of heat that could be easily and accurately controlled, and that could automatically be kept constant. It also had to allow of the obtaining and maintaining of the desired furnace atmosphere.

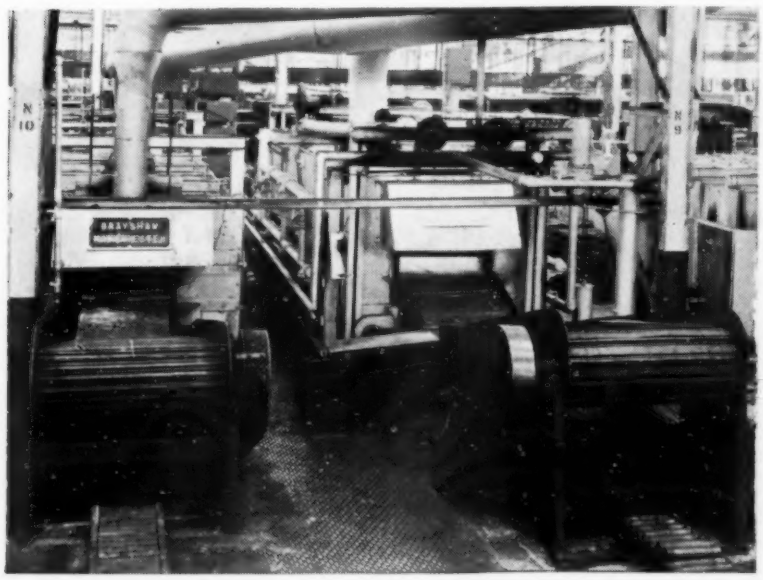
Without critical control of temperature, atmosphere and speed of transit at each stage of the operation, these furnaces would not have been practicable. The desired results could not have been assured, and the number of rejects would have been excessive.

The ideal form of heat for this type of furnace has been found in coal gas. Town gas is of known and constant calorific value, and is available in a ready-to-burn form in almost unlimited quantities. It can be burnt in the widest variety of different burners, which can be accurately controlled, singly or in a set, to give a constant heat input, distributed in any required way. By means of thermostats it is easily possible to provide automatic maintenance of any desired temperature.

All this is additional to the many other advantages of town gas such as the saving in space and labour, the greatly increased life of the furnace due to its use—refractories last longer, and its greater reliability and cleanliness. Comparing its cost on the true basis of the quality and cost of the finished article, town gas is quite the cheapest fuel that can be used.

There is a treatise—entitled "The Heat-Treatment of Steel"—issued free by the British Commercial Gas Association, which contains a fund of valuable information on the subject and is well worth sending for. It can be obtained from most local gas undertakings, or from the Association" address, 28, Grosvenor Gardens, London, S.W. 1.

All needing expert advice on gas equipment should write to the Association, who will put the enquirer in touch with the body best equipped to assist him.



Two normalising furnaces at the Ford works.

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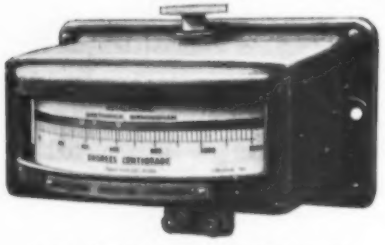

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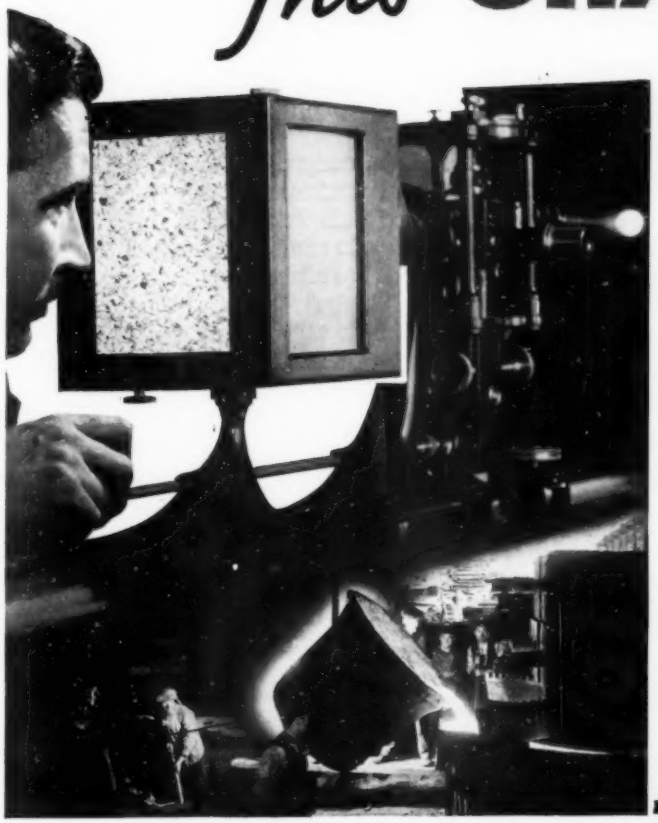

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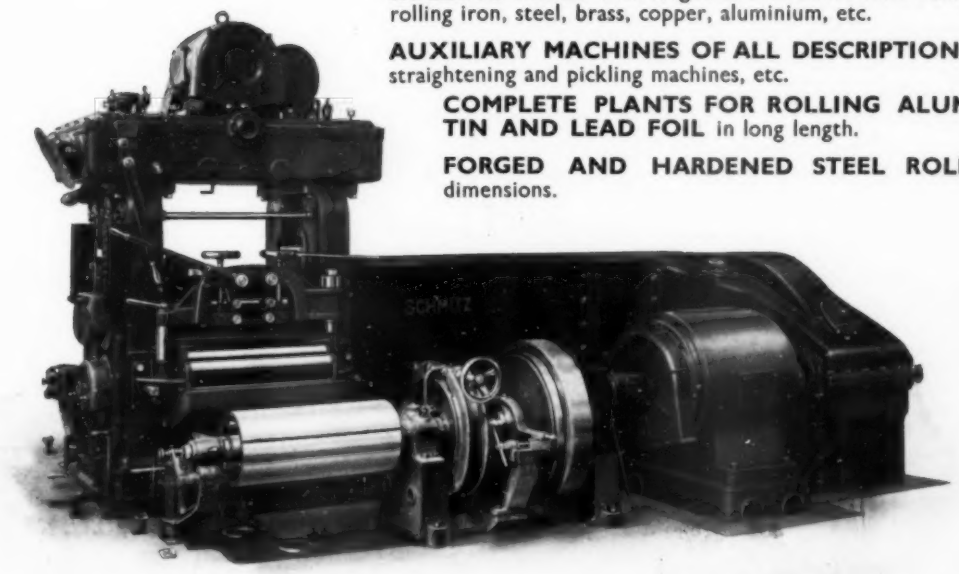

Town Gas in the Heat Treatment of Steel

ITS ADVANTAGES IN OBTAINING CONSISTENT RESULTS

(From "The Heat Treatment of Steel")

THE term "heat treatment of steel" covers a wide variety of processes, the requirements of which, with regard to temperature, furnace atmosphere, time of soaking in the furnace, etc., necessarily differ considerably. The choice of fuel for any given operation must therefore depend largely on conditions relating to that operation alone. It cannot be too highly stressed, however, that the choice of a fuel solely on the cost per B.Th.U. does not ensure the selection of the most economic fuel, since it takes no account of faulty work, to say nothing of additional labour, plant replacements and other factors which must be taken into account in arriving at the total cost of the operation. It is the growing realisation that the only true criterion is the quality and cost of the finished article that is largely responsible for the increasing use of town gas in the various heat treatment processes.

Fuel utilisation, in so far as heat treatment is concerned, consists in converting the potential heat in coal or oil into useful heat in a furnace. In practice, if a fuel is to be burned under the best conditions it has to be gasified. In the case of coal and coke this is done partially in the furnace combustion chamber, in the case of oil by the burner, in the case of producer gas in the producer, and in the case of town gas in the gasworks. Accurate control of the useful heat in the furnace depends on the quality of the gas being burned and the degree to which its combustion can be controlled. The main difference between town gas and the other fuels is that the raw fuel is taken through all but the last stage in its conversion into useful heat by the gas undertaking instead of by the consumer; just as in other industrial processes, specialisation and large scale working give better quality at less cost. That is the fundamental reason why a town gas-fired furnace gives the best control of the useful heat put into the work. In practice the difference between town gas and the other fuels is that, owing to its convenient form and constant calorific value, it can be burnt in the widest variety of different burners which can be controlled singly or as a set to give a constant heat input distributed in any required way.

Furnace Requirements in Heat Treatment

In general the chief requirements of a furnace for heat treatment may be set out as follows:—

1. *The provision of a definite temperature, which will not vary beyond certain defined limits.*
2. *The maintenance of a uniform or suitably graded temperature throughout the furnace chamber, for any desired time.*
3. *Reliability and ease of control, requiring the minimum of attention; and low maintenance costs.*
4. *Ease and speed in heating up the furnace to the required temperature.*
5. *The provision of a suitable and controllable atmosphere within the furnace chamber in order to ensure any desired effect on the surface of the metal treated.*
6. *The maintenance of a clean shop with good working conditions.*

Accurate control of the temperature to which the steel is heated in any heat treatment process is an obvious necessity. The permissible tolerance varies with the different processes, but for accurate work a tolerance of $\pm 5^\circ$ C. may be regarded as adequate. Accuracy of this order is attainable in properly designed modern gas furnaces, especially when automatic temperature control is used. Unfortunately it is not sufficient that the pyrometer reading should remain within the prescribed limits. The load is what matters and unless all parts of the load are maintained within those limits the quality of the product will suffer. Uniformity of temperature can only be obtained by careful furnace design and accurate adjustment of all burners and flues. These adjustments will only remain accurate if the fuel characteristics are uniform and hence the importance of using a high-grade fuel. It is a great advantage of town gas that it can be burnt in burners of almost any size so that where it is difficult to obtain the required heat distribution with one burner or combustion chamber it is possible to use a number of burners, each separately adjustable. If work is to be carried out to schedule with the minimum of waste, furnaces must be reliable in themselves and depend as little as possible on the human element, which is always liable to error. If the furnaces are to be relied on the reliability of the fuel supply is of the first importance. Town gas is the most reliable of fuels.

Reliability of Furnace Structure

Closely allied to reliability of the fuel supply is reliability of the furnace structure. Unexpected failure of refractories may have even worse consequences than failure of the fuel supply, while routine maintenance in addition to being costly adds one more care to the works manager's already harassed life. A fuel which reduces the frequency of refractory maintenance work therefore has a very tangible advantage over others. The disposition of the burners and the quality of the flame can be so readily adjusted with town gas that refractory life is generally much longer than with other fuels.

In heat treatment atmosphere control may be as important as temperature control, and is more easily obtained with town gas than with any other fuel.

A store of invaluable information on the heat treatment of steel and on furnace practice is contained in the treatise issued by the British Commercial Gas Association entitled "The Heat Treatment of Steel." It is issued quite free on application to the Association's address, Gas Industry House, 1, Grosvenor Place, London, S.W. 1.

All needing expert advice on furnace practice should write to the Association, who will put the inquirer in touch with the body best equipped to assist him.

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UP-TO-DATE VITREOUS ENAMELLING PLANT

NOWHERE has there been such a considerable expansion of the use of vitreous enamelling as in the manufacture of domestic gas apparatus—cookers, water-heaters, boilers, etc. It seems appropriate, therefore, that this industry should take a lead in the use of town gas for the various furnaces used in vitreous enamelling.

Town gas is not quite so cheap a fuel as oil, taking the fuel costs alone, but it brings about many indirect savings, which far more than compensate for the small difference in cost, and, in the long run, town gas proves quite the most economical and certainly the most satisfactory fuel for vitreous enamelling furnaces.

Less labour is required with a gas-fired furnace than with any other type. Usually, one fuser, with one or two assistants to help with loading and unloading, is sufficient. One furnace attendant can look after the temperature of a number of furnaces. One reason for this is that town gas allows for more accurate and easy control of temperature.

Very often, advantage is taken of this ease of control to introduce a thermostat, and so make the control automatic. Thermo-couples in the roof of the furnace operate an electric relay which regulates the gas input.

Reducing Rejects

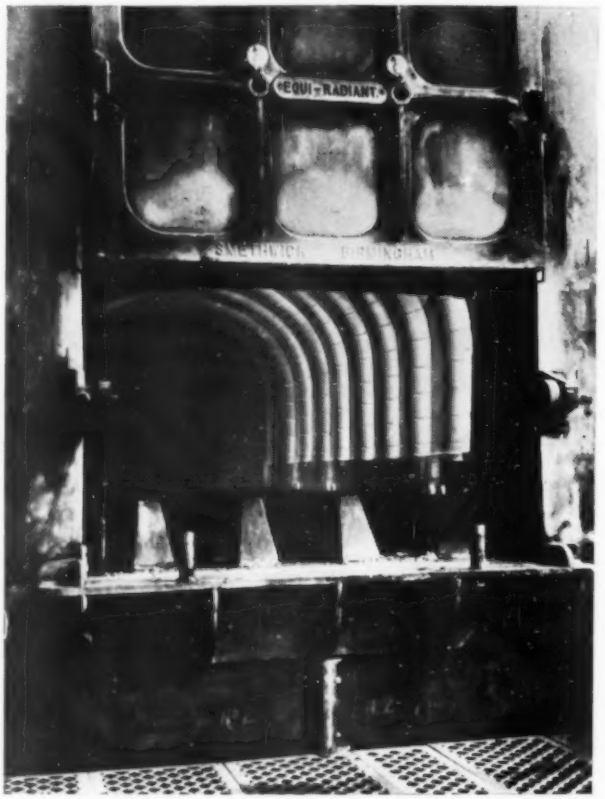
Accurate control of temperature goes a long way to reduce the number of rejects. With gas-firing, the furnace conditions are under complete control. That allows any furnace condition to be obtained and maintained, and that is half the battle in eliminating faulty work.

Refractories last longer on town gas, too, and this can mean a considerable saving. It is also found that gas does not deposit carbon on the jets and so cause stoppages.

A Modern Gas-fired Furnace

An example of an up-to-date gas-fired enamelling furnace is that installed at the works of one of the leading manufacturers of domestic gas appliances. It is one of the new radiant tube furnaces.

With these furnaces the hot gases from the burners pass through refractory tubes which surround the working space. These tubes can be seen through the furnace door in the illustration. From them the gases pass into a recuperator below the furnace hearth and out to a main flue at the back. Not only does this system provide an exceptionally large area of incandescent refractory material, which heats the work by radiation, but it also promotes convection currents in the working space which increase the rate of heat transfer and help to even out the temperature throughout the load. In addition, each tube can be separately controlled, which enables the space near the door to be kept at the same temperature as the rest of the furnace. The result is to enlarge the effective working space in the furnace, and so increase its throughput.



Gas-fired radiant tube furnace for vitreous enamelling.

Rear view of the above furnace.

This furnace operates with low-pressure gas and natural draught only, so that a slight negative pressure is obtained in the flue system, which prevents the products of combustion from entering the working space even if there is a crack in the refractory wall. A working temperature of 750° C. to 950° C. is maintained.

This company works its furnaces continuously for 24 hours for six days a week. The continuous working saves fuel and time in the heating up, and also saves the refractories, for refractories suffer under constant variations of temperature.

The British Commercial Gas Association issue a very informative publication, entitled, "Town Gas for Vitreous Enamelling," which is well worth sending for. It is available, quite free, from their address—Gas Industry House, 1, Grosvenor Place, London, S.W. 1. All needing expert advice on the subject should write to this address, and they will be put in touch with the body best equipped to assist them.

Enamelling the Raleigh Cycle

Continuous production methods assisted by gas-fired ovens

THE Raleigh Cycle Company turns out 500,000 cycles a year. That output offers full scope for modern continuous production methods, and the Raleigh Company take full advantage of it.

One of the most important operations in the production of a cycle is that of enamelling. For this operation the Raleigh Company use seven gas-fired conveyor ovens. The use of town gas for enamelling ovens is spreading as it has many very important advantages.

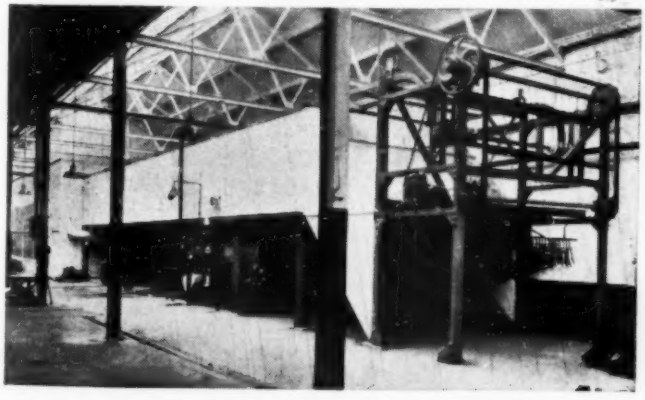
The first advantage is its reliability. The gas supply never fails. It is always there in almost limitless quantities at a fixed price. The second advantage is that with a clean fuel like town gas a direct-fired air heater can be used in most cases where an indirect type would have to be used otherwise. Not only does this save fuel, but it simplifies and cheapens the maintenance of the oven, for air heater elements are made of expensive material and have to be replaced regularly.

No fuel can be so easily and accurately controlled as town gas. Oven temperatures can be accurately controlled with the simplest thermostats. The required oven conditions can be more readily obtained with town gas than with any other fuel. Another advantage is the saving in space and labour, for gas requires no storage or handling and calls for less cleaning work and supervision.

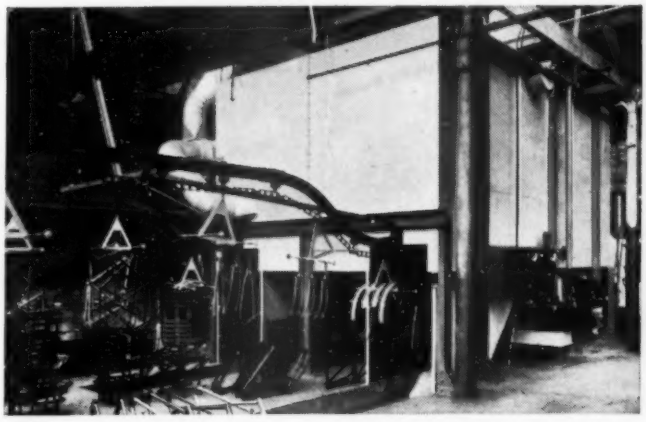
The Raleigh oven described

Cycle frames at the Raleigh works are enamelled in black and also various colours. These two groups are dealt with quite separately.

The standard black finished models are stoved in conveyor ovens measuring 56 ft. long by 9 ft. 6 in. wide by 5 ft. 6 in. high inside. One of these ovens is illustrated here.



Gas-fired conveyor enamelling oven for black cycle parts.



Gas-fired conveyor enamelling oven for coloured finishes.

At the inlet end of each oven is a tiled dipping room. The parts undergo a three coat process and, as the average capacity of the plant is 10,000 complete cycles per week, some idea can be obtained of the immense number of parts treated.

Each oven is heated by an automatically controlled direct gas-fired air heater and is provided with a recirculating system.

Ingoing air and products of combustion are maintained at 500° F., providing a constant temperature of 460° F. in the oven. The chain conveyor passing through the oven is driven through a variable-speed gear by a 1 h.p. motor, giving conveyor speeds of 3½ ft. to 4½ ft. per min.

Colour finishes are dealt with in an oven measuring 25 ft. by 12 ft. by 9 ft., also illustrated here. In this oven the entry and exit of the conveyor chain are both at the same end, the chain making four passes up and down the oven chamber during one hour—the time of stoving.

Small parts are dealt with in a similar oven. These number up to 650,000 a week.

The question of cost

Estimating the comparative costs of fuels is no easy matter. It is entirely misleading to consider the fuel costs alone as the fuel influences so many other costs, all of which vary with circumstances. Taking all in all, however, it is now being widely realised that the use of town gas is an economy. Its saving in labour, space and furnace maintenance more than compensates for any extra cost of the fuel there might be.

All needing expert advice on gas equipment should write to The British Commercial Gas Association, Gas Industry House, 1, Grosvenor Place, London, S.W. 1, who will put the inquirer in touch with the body best equipped to assist him.

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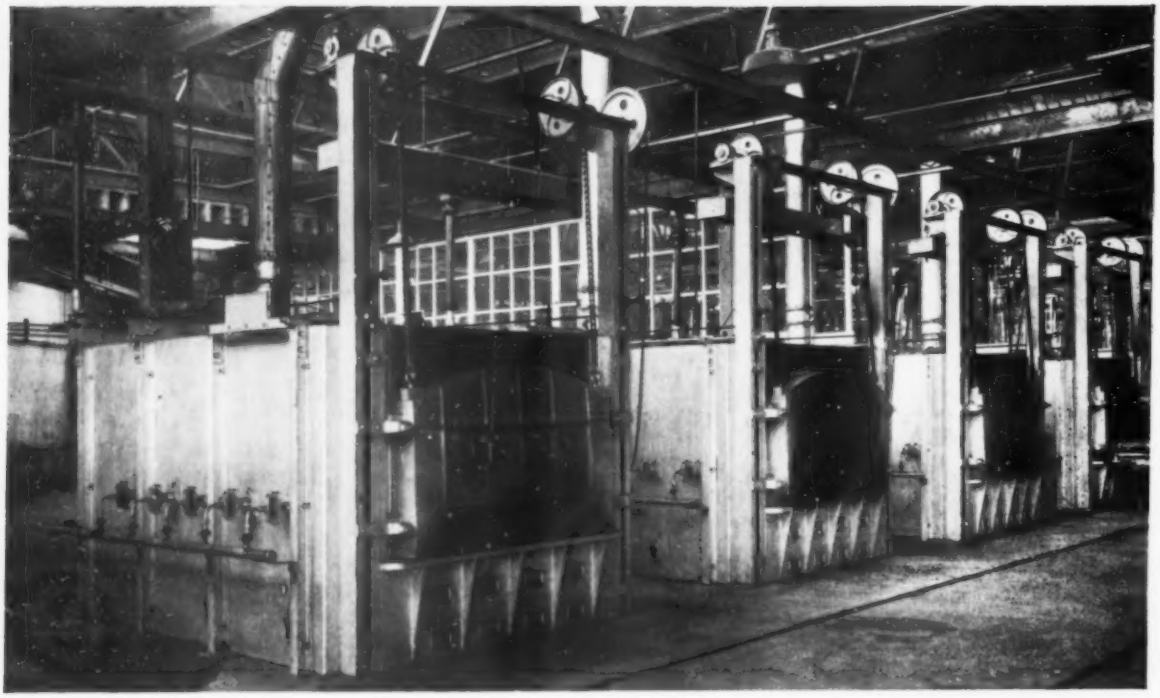

Four of a group of ten Gibbons' town's gas-fired carburizing furnaces, fitted with Electroflo automatic control, at the works of Messrs. Wolseley Motors (1927) Ltd.

Reliable results sought in heat-treating practice depend upon the proper combination of the man, the furnace, and the material. Good material is entitled to proper treatment in good furnaces, and both should have the services of good men.

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